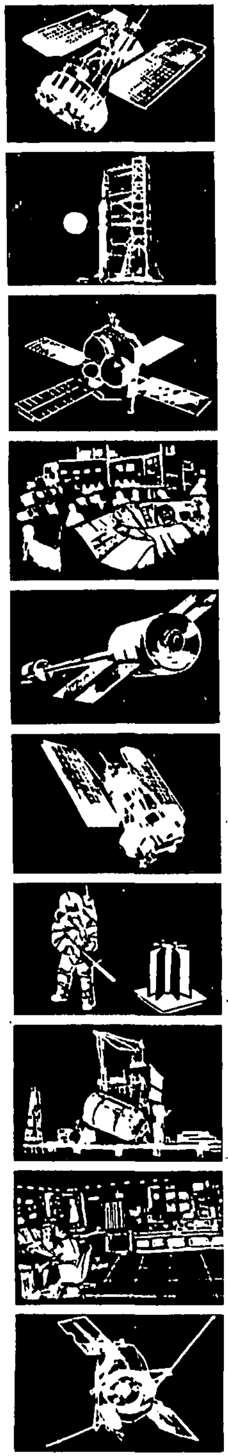
N76-27309

JULY 1, 1976

SPACE DIVISION

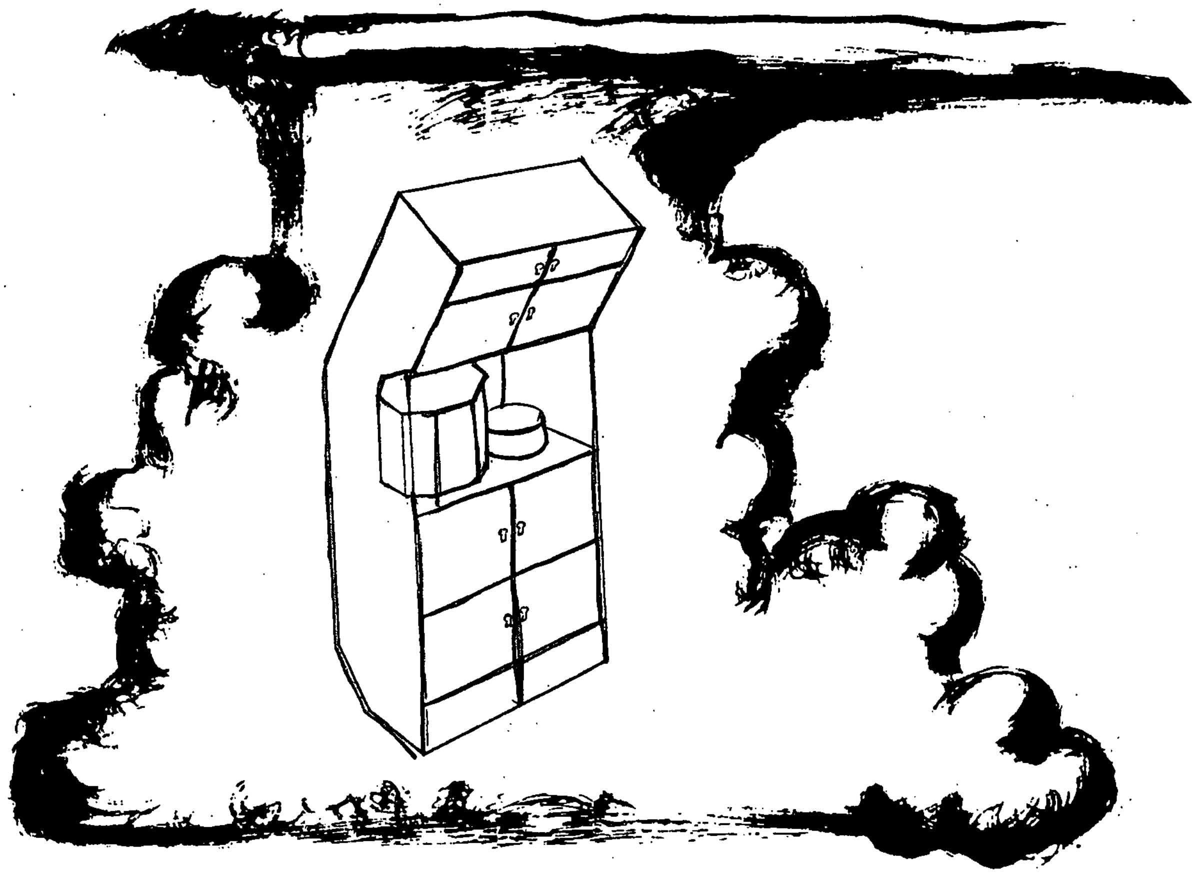


Final Definition And Preliminary Design Study for The Initial

ATMOSPHERIC CLOUD PHYSICS LABORATORY

A Spacelab Mission Payload

NAS 8-31845



CONCEPT REVIEW
DR MA-03

GENERAL ELECTRIC

ATMOSPHERIC CLOUD PHYSICS LABORATORY

CONCEPT REVIEW

JULY 1, 1976

Page Intentionally Left Blank

PRESENTATION OUTLINE

INTRODUCTION/CONCEPT OVERVIEW - R. GRECO

ACPL DESIGN/FUNCTIONAL FEATURES - L. EATON

- CLOUD CHAMBERS
- HUMIDIFIER
- GENERATORS/CONDITIONERS
- CHARACTERIZERS
- OPTICS/IMAGING

ACPL DESIGN/FUNCTIONAL FEATURES - G. FOGAL

- THERMAL CONTROL
- FLUID
- AIR CLEANING
- CONTROL AND DATA
- POWER DISTRIBUTION
- GSE/STE
- ACPL CONFIGURATION

PROGRAMMATICS - R. BIRMAN

- OPERATIONS ANALYSIS
- SCHEDULES
- COST
- CEI'S/ICD'S

SUMMARY - R. GRECO

Page Intentionally Left Blank

INTRODUCTION

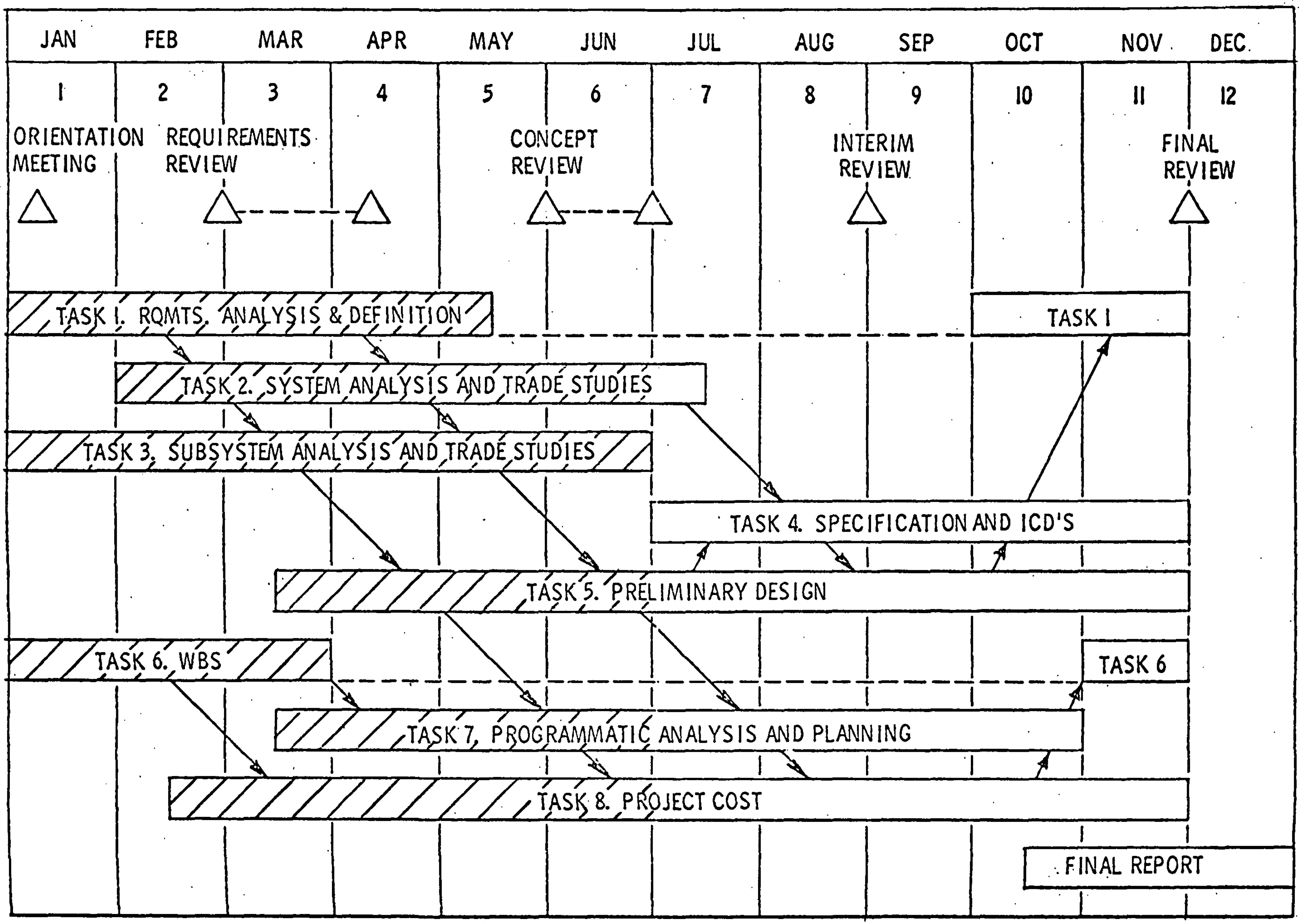
CONCEPT OVERVIEW

R. GRECO

ACPL STUDY SUMMARY FLOW

THE ACPL STUDY TASK FLOW IS SHOWN. PROGRESS TO DATE IS IDENTIFIED. THE REQUIREMENTS GENERATED IN TASK 1 HAVE BEEN USED TO FORMULATE AN INITIAL ACPL BASELINE DESIGN CONCEPT.

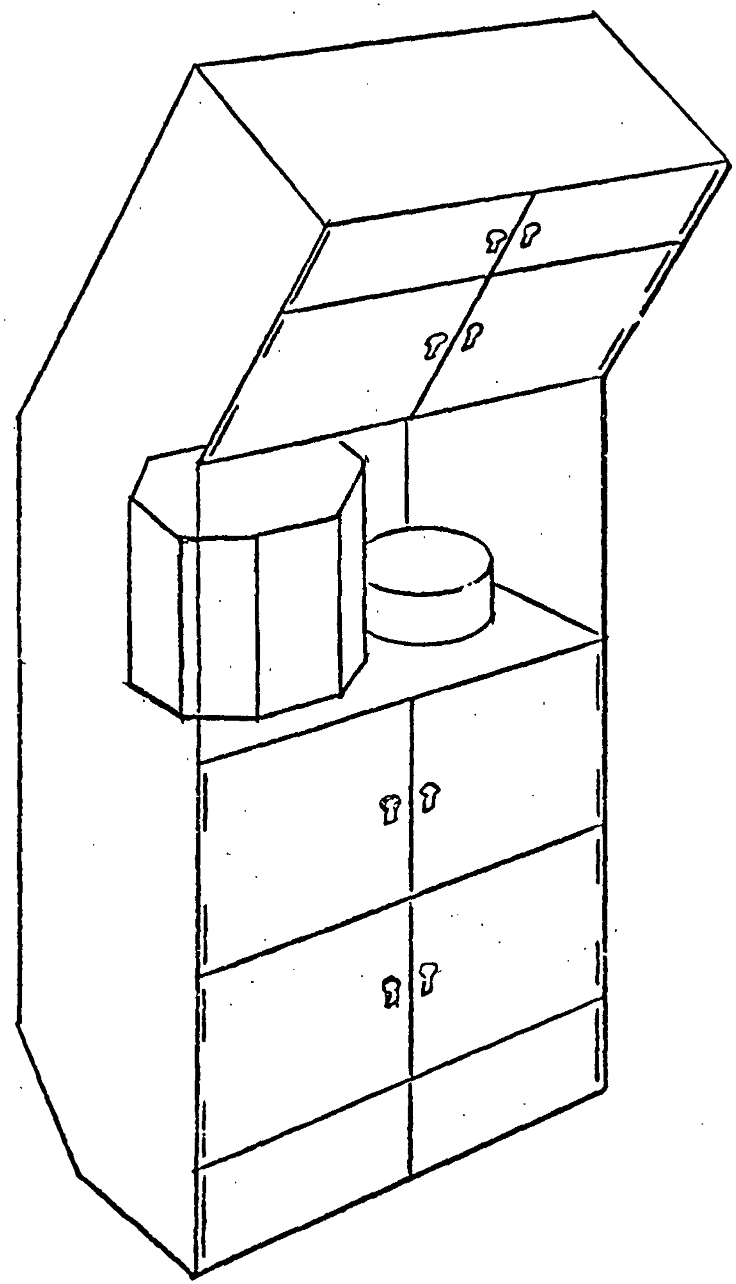
ACPL STUDY SUMMARY FLOW



INITIAL ACPL BASELINE DESIGN CONFIGURATION

THE ACPL CONFIGURATION HAS BEEN REVISED AND UPDATED AS A RESULT OF THE DESIGN AND ENGINEERING ANALYSES PERFORMED SINCE THE REQUIREMENTS REVIEW. THE CURRENT CONFIGURATION PROVIDES FOR FIXED CLOUD CHAMBER MOUNTING WITHIN THE SPACELAB RACK CONFIGURATION. INITIAL RESULTS INDICATE THAT A SUFFICIENT RESERVE OF VOLUME EXISTS TO ACCOMMODATE ACPL GROWTH.

INITIAL ACPL



MAJOR ACPL EQUIPMENT

THE FACING PAGE LISTS THE MAJOR EQUIPMENT THAT HAS BEEN INCORPORATED INTO THE ACPL DESIGN. THIS COMPLEMENT OF EQUIPMENT AND THEIR RESPECTIVE DESIGN FEATURES PROVIDES A VERY VERSITILE AND FLEXIBLE FACILITY WHILE MEETING THE EXACTING DESIGN GOALS RESULTING FROM THE PREVIOUSLY DEFINED SCIENTIFIC REQUIREMENTS.

MAJOR ACPL EXPERIMENT EQUIPMENT

CHAMBERS

- CFD
- E
- SDL

GENERATORS AND CONDITIONERS

- ATOMIZATION - EVAP/COND
- PHOTO/CHEMICAL CONDITIONER
- DIFFUSION BATTERY
- ELECTROSTATIC CLASSIFIER
- AEROSOL NEUTRALIZER(S)
- AEROSOL COAGULATOR

CHARACTERIZERS

- THERMAL PRECIPITATOR SAMPLER
- CONDENSATION NUCLEI COUNTER
- ELECTRICAL AEROSOL DETECTOR
- OPTICAL PARTICLE COUNTER

OPTICAL AND IMAGING

- CAMERA (MOTORIZED 35 MM)
- FILM
- OPTICS
- LIGHT SOURCE(S)

BROAD FLEXABILITY FOR AEROSOL RESEARCH

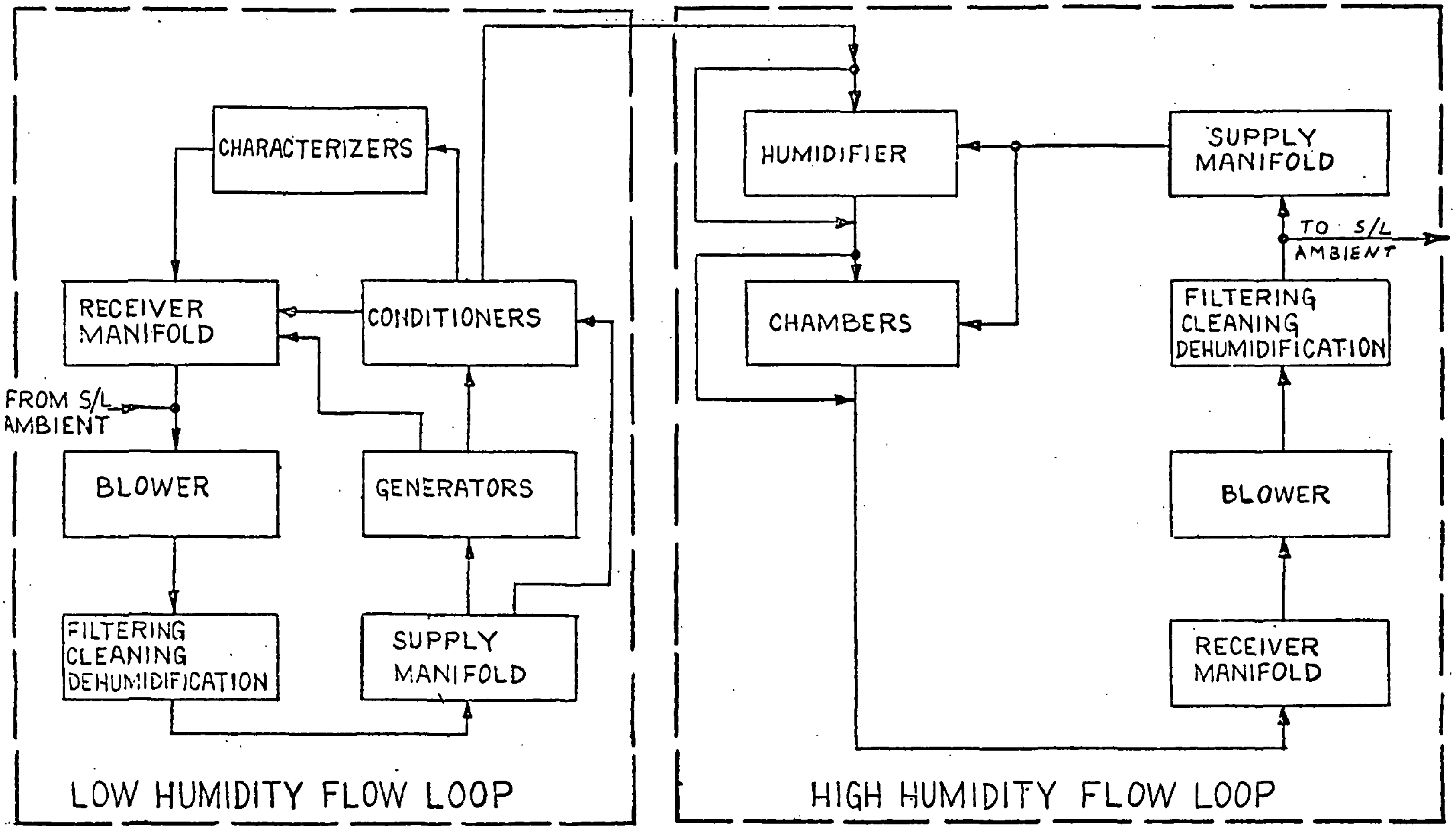
ACPL DESIGN/FUNCTIONAL FEATURES

L. EATON

ACPL FUNCTIONAL SYSTEM SCHEMATIC

THIS SYSTEM AND ITS CONTROL PROVIDES AN EFFICIENT AND PRECISE DELIVERY OF AIR AND AEROSOL TO THE EXPERIMENT CHAMBERS. AN ON-LINE STABLE GENERATOR PROVIDES A CONTINUOUS AEROSOL SOURCE. THE CONDITIONERS PROVIDE A NUMBER OF AEROSOL SHAPING OPTIONS WHILE THE CHARACTERIZERS PROVIDE REAL TIME MEASUREMENTS AND HARD SAMPLE OF THE AEROSOL. THE CHAMBER LOOP PROVIDES VERSITILE OPERATION OF SINGLE OR MULTIPLE CHAMBERS OVER A TEMPERATURE RANGE OF $-25^{o}C$ TO $+20^{o}C$.

ACPL FUNCTIONAL SYSTEM SCHEMATIC



Page Intentionally Left Blank

CONTINUOUS FLOW DIFFUSION CHAMBER
(CFD)

CFD FEATURES

THE CFD DESIGN PROVIDES FOR THE CONTROL OF S_M TO BETTER THAN 1% ACCURACY DOWN TO A S_M OF 0.2% AND TO BETTER THAN 5% ACCURACY DOWN TO AN S_M OF 0.01%. THE EXTERNAL/INTERNAL WATER RESERVOIR SYSTEM MAKES THE CFD INSENSITIVE TO LAUNCH FACTORS AND INDEPENDENT OF MISSION DURATION. NOMINAL OPERATING POWER ABOVE 0°C IS 20 TO 30 WATTS.

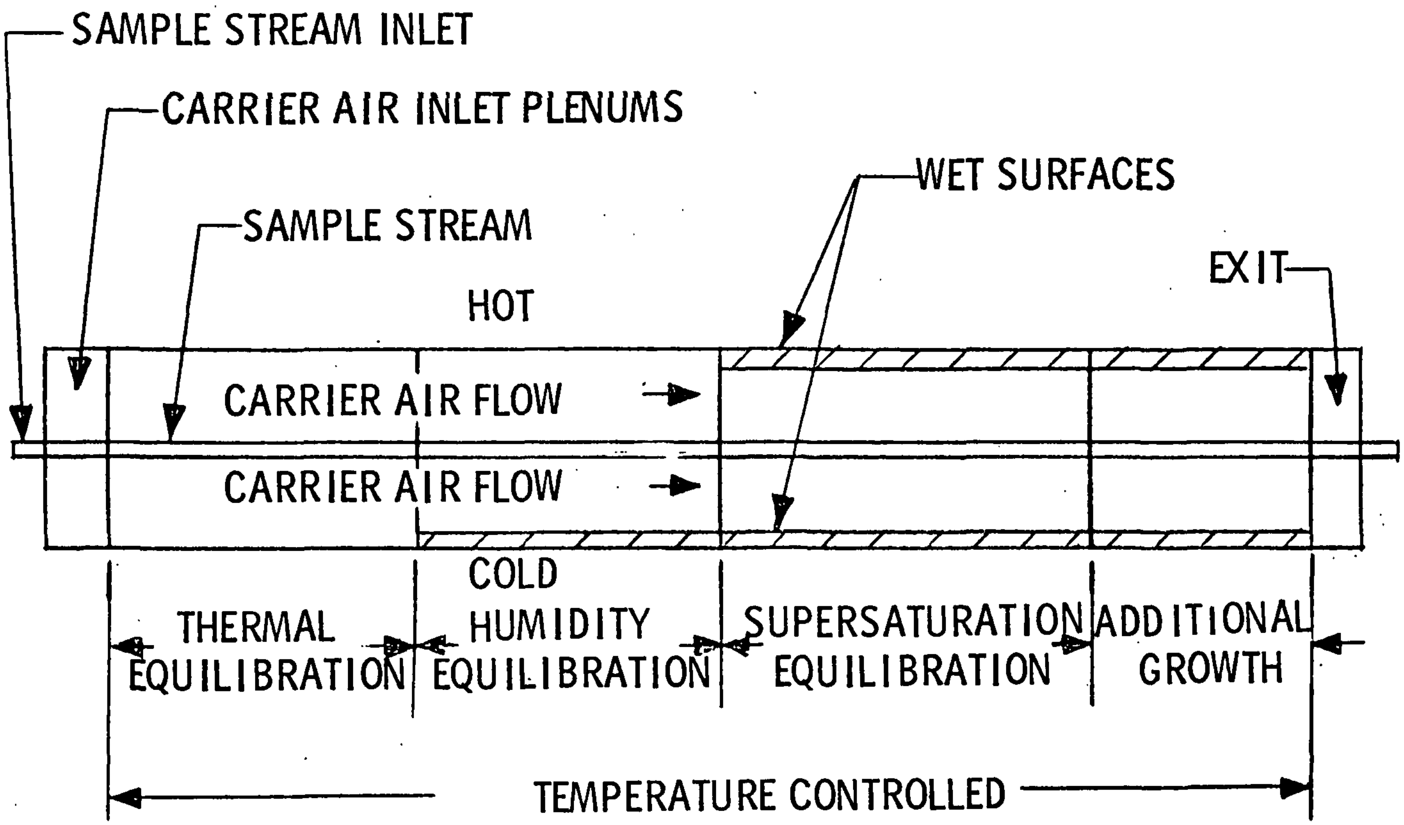
CFD FEATURES

- INTERNAL DIMENSIONS: WIDTH - 40 CM, LENGTH - 43.5 CM, PLATE SPACING - 2 CM
- CONTROLLED GROWTH ZONE RESIDENCE TIME <1 SEC TO >50 SEC
- ACTIVATION REGION TEMPERATURE RANGE $-25^{o}C < T < 20^{o}C$
- ABSOLUTE TEMPERATURE CONTROLLED/MONITORED TO $\leq 0.1^{o}C$
- RELATIVE PLATE TEMPERATURES CONTROLLED/MONITORED TO $\leq 0.01^{o}C$
- CFD DIFFERENTIAL PLATE TEMPERATURE RATE OF CHANGE $>2^{o}C/MIN$
- ACTIVATION REGION TEMPERATURE FIXED FOR A SET OF S_M's
- AEROSOL SAMPLE POSITION ADJUSTABLE
- BYPASS AEROSOL FLOW MINIMIZES INJECTED AEROSOL LOSSES

CFD CROSS-SECTION SCHEMATIC

THE FOUR KEY INTERNAL ZONES, ILLUSTRATED ON THE ADJACENT PAGE, MUST BE TREATED BOTH INDEPENDENTLY AND TOGETHER IN ORDER TO SATISFY THE CFD DESIGN OBJECTIVES. ZONE LENGTHS ARE DETERMINED FROM DIFFUSION TIME CONSTANT AND FLOW VELOCITY CONSIDERATIONS, CHAMBER INTERNAL WIDTH IS A FUNCTION OF AEROSOL THROUGHPUT RATE AND OUTER WALL EFFECTS AND THE PLATE SPACING IS PRIMARILY CONTROLLED BY VAPOR DEPLETION AND PHORETIC DIFFUSION.

CFD CROSS-SECTION SCHEMATIC



o KEY FACTORS TO BE DETERMINED

- FOUR ENVIRONMENT CONTROLLED ZONES
- VARIABLE ΔT (HOT-COLD)
- THREE AIR FLOWS (TWO CARRIERS AND A SAMPLE)
- PRE AND POST ZONES (INLET, OUTLET)
- SAMPLE INJECTION

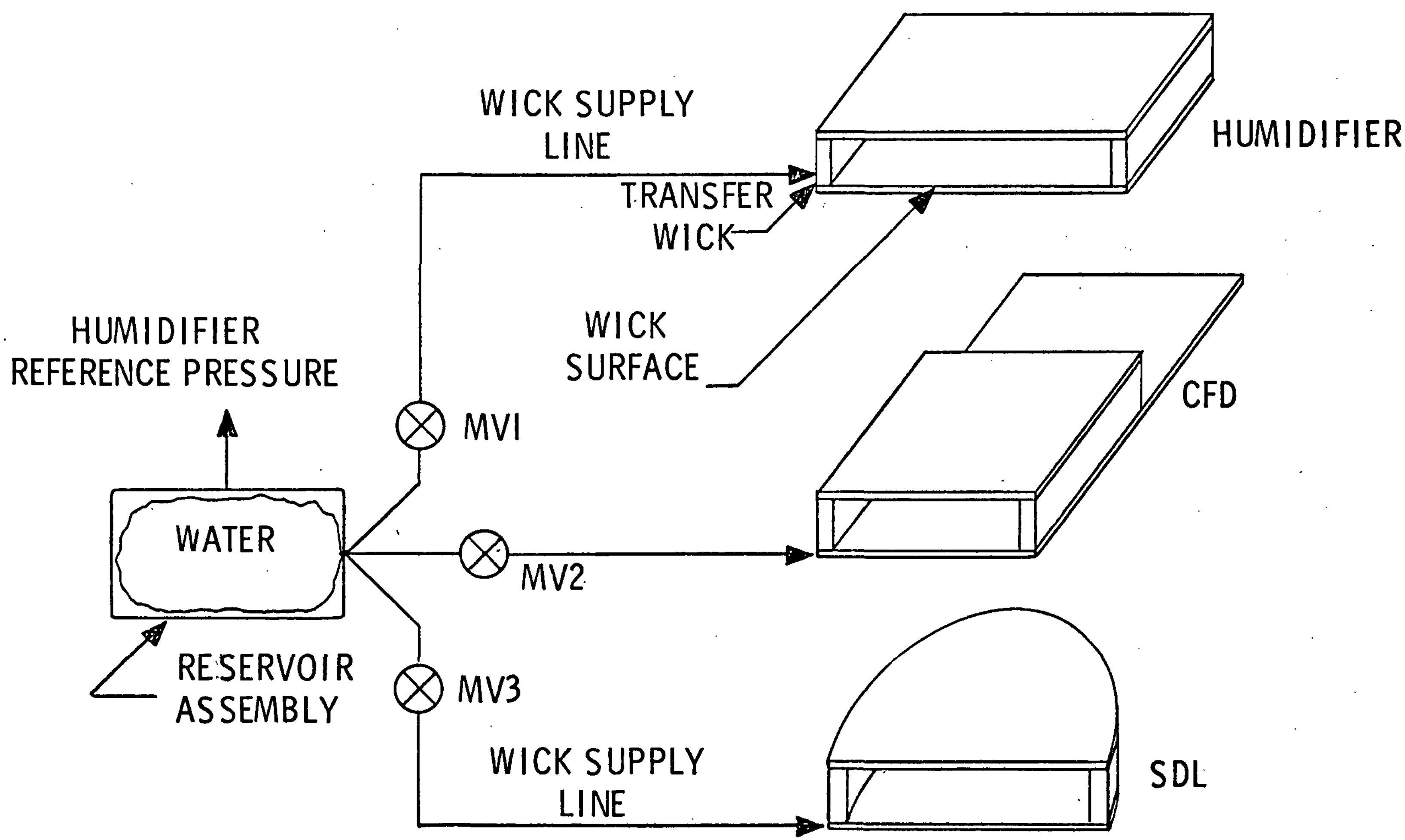
WATER SUPPLY

(CFD, SDL, HUMIDIFIER)

ACPL WICKED WATER SURFACES SUPPLY ASSEMBLY

THE ADJACENT PAGE ILLUSTRATES THE WICKED SURFACE PORTIONS OF THE HUMIDIFIER, CFD AND SDL AND THEIR COUPLING TO THE WATER RESERVOIR. DESIGN PROVIDES LAUNCH FACTORS INDEPENDENCE AND EXPERIMENT DURATION FLEXIBILITY.

ACPL WICKED WATER SURFACES SUPPLY ASSEMBLY



EXPANSION CHAMBER
(E)

EXPANSION CHAMBER FEATURES

THE EXPANSION CHAMBER VOLUME AND THE THERMAL/PRESSURE CONTROLS WILL PROVIDE AN ADIABATIC EXPANSION IN EXCESS OF SEVERAL HUNDRED SECONDS LIMITED PRIMARILY BY THE ACCURACY OF THE PREPROGRAMMED P/T PROFILES OR BY THE ABILITY OF A CLOSED LOOP FEEDBACK PROCEDURE (SENSOR PLUS COMPUTER MODEL) TO PROVIDE THE APPROPRIATE PRESSURE/TEMPERATURE PROFILES. INITIAL PRESSURES BELOW 400 MB CAN BE ACCOMMODATED.

EXPANSION CHAMBER FEATURES

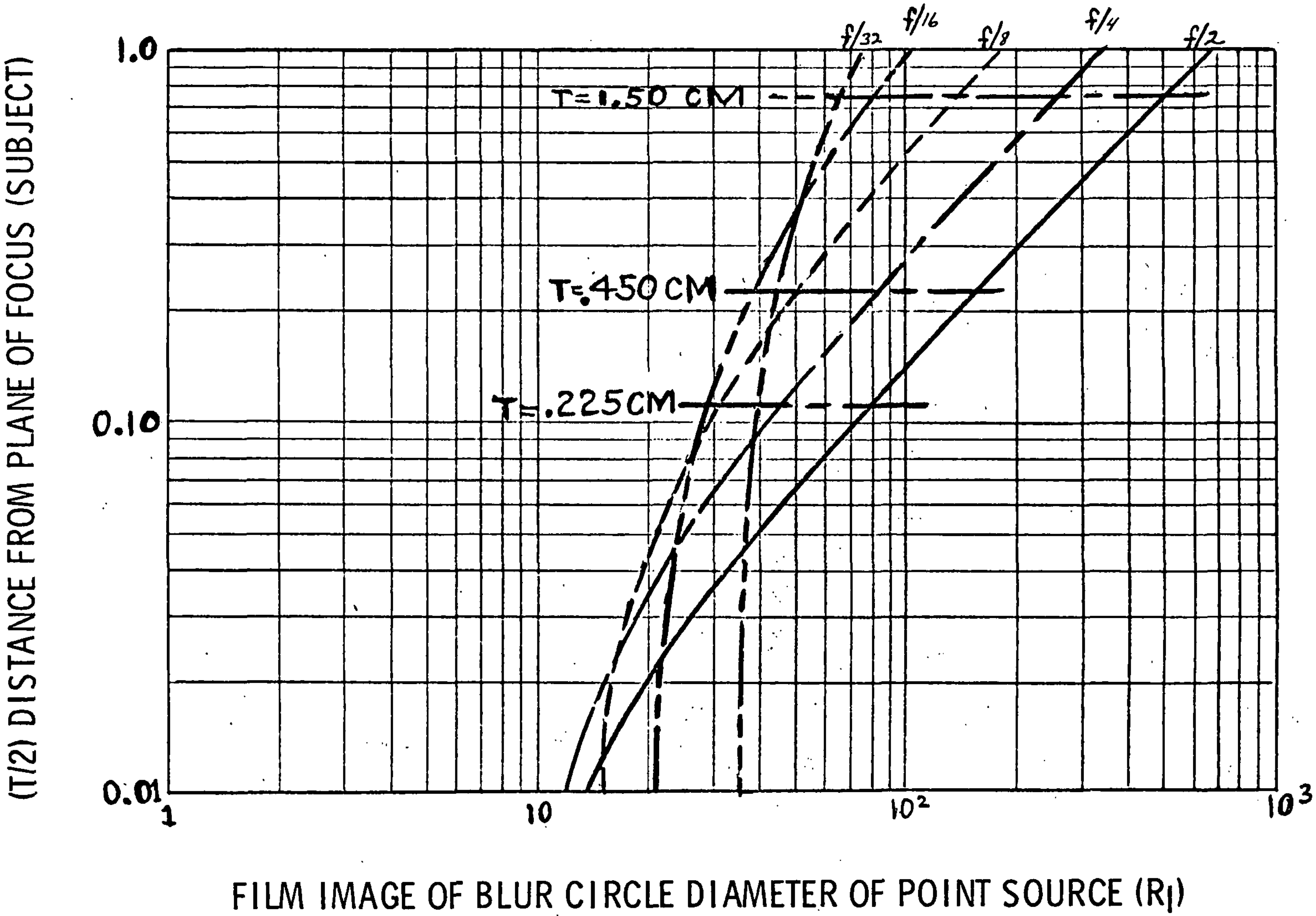
- INTERNAL DIMENSIONS: DIAMETER - 38 cm, LENGTH - 27 cm, VOLUME - 30.6 L
- SENSITIVE EXPERIMENT VOLUME (SEV): 100 cm^3
- INITIAL PRESSURE RANGE: $\leq 400 < P < 1013$ mb
- PRECISION EXPANSION RANGE: UP TO 500 mb
- PRESSURE PROFILE ACCURACY: $\leq \pm 0.1$ mb
- WALL TEMPERATURE CONTROL RANGE: $-25^{\circ}C < T < +20^{\circ}C$
- ABSOLUTE WALL TEMPERATURE CONTROL/MONITORED TO: $\leq 0.1^{\circ}C$
- RELATIVE WALL TEMPERATURES CONTROLLED/MONITORED TO: $\leq 0.01^{\circ}C$
- INNER WALL SURFACE COOL DOWN RATE: $\geq 6^{\circ}C/MIN$
  - LOW POWER
  - FAST RESPONSE
- OBSERVATION AND PROBE PORTS

E CHAMBER OPTICS RESOLUTION

THE ADJACENT PAGE SHOWS THE AMOUNT OF FILM IMAGE BLUR AS A FUNCTION OF DISTANCES FROM THE PLANE OF FOCUS (SUBJECT) FOR SEVERAL EFFECTIVE F/ .,

6.3 CM F/13.5 LENS WAS SELECTED AS A TRADE BETWEEN BLUR CIRCLE SIZE AND ITS UNIFORMITY OF SIZE THROUGHOUT THE DEPTH OF FIELD. THE VARIOUS HORIZONTAL "T" LINES ARE DEPTH OF FIELD MASK POINTS USED TO ENHANCE IMAGE RESOLUTION FOR HIGH PARTICLE CONCENTRATIONS.

E CHAMBER OPTICS RESOLUTION



OPTICS SUMMARY (E)

THE E CHAMBER OPTICS CAPABILITY IS SUMMARIZED ON THE FACING PAGE. THE SEV OF 100 CM^3 WILL PROVIDE A MAXIMUM OF 1% ERROR FOR PARTICLE CONCENTRATIONS BETWEEN 100 TO 1,000 PARTICLES PER CUBIC CENTIMETER.

OPTICS SUMMARY (E)

T	PARTICLE IMAGE SIZE	PARTICLE SUBJECT RESOLUTION	MAX. CONCENTRATION
1.50 cm	21 TO 82 μm	59 TO 228 μm	128 K cm^{-3}
.450 cm	21 TO 39 μm	59 TO 109 μm	568 K cm^{-3}
.225 cm	21 TO 30 μm	59 TO 84 μm	960 K cm^{-3}

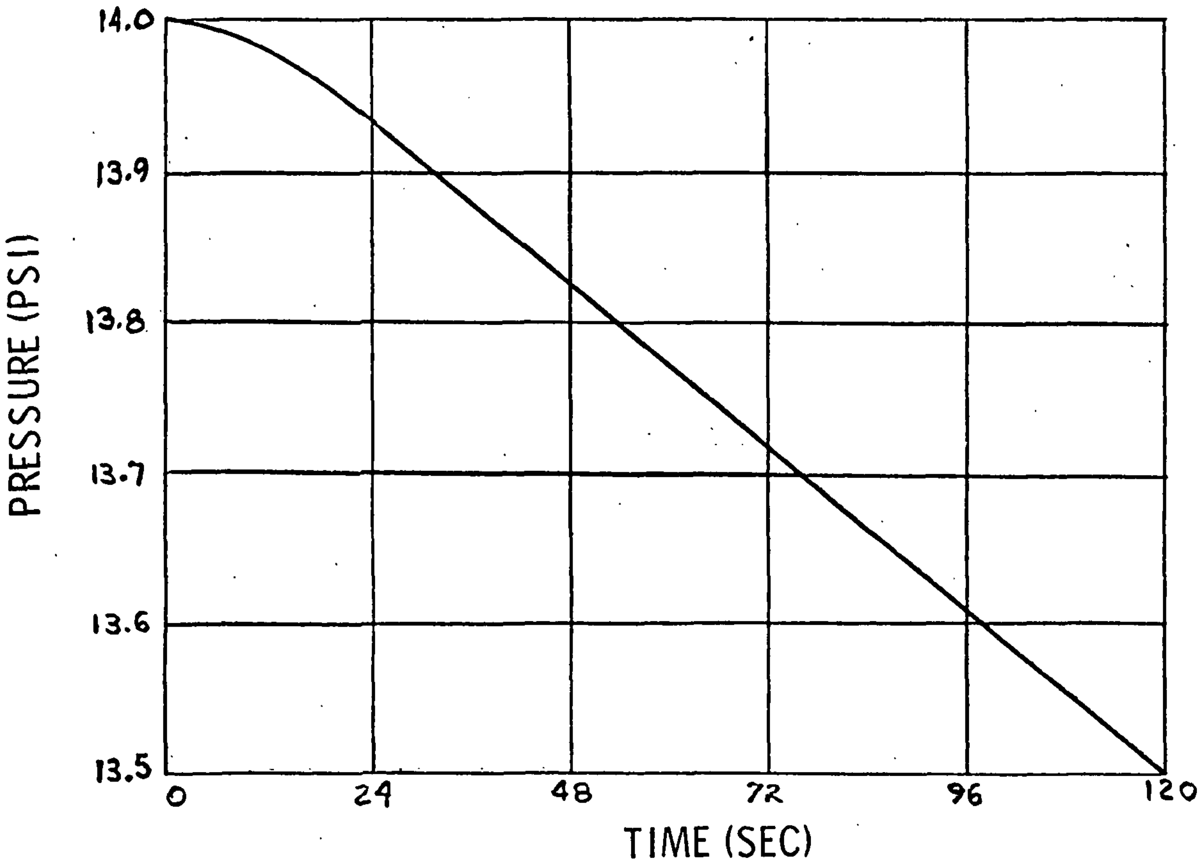
- f/13.5 SELECTED
- IMAGE SIZE = IMAGE BLUR CIRCLE + PARTICLE SIZE x MAGNIFICATION
- T (SUBJECT DEPTH) = 1.50 cm
- T = 0.450, 0.225 CONTROLLED BY TWO MASKS
- FULL 30 mm FILM FORMAT 6.67 cm x 10 cm
- CAMERA WINDOW: 3.3 x 4.3 cm CLEAR APERATURE
- ILLUMINATOR WINDOW: 1.50 cm x 6.67 CLEAR APERATURE

SEV 6.67 cm x 10 cm x 1.50 cm

CLOUD FORMATION TEMPERATURE PROFILE (UMR)

EITHER THE P OR T PROFILE CAN BE SPECIFIED AS A LINEAR RAMP AND THE OTHER PROFILE MADE TO FOLLOW. THE ADJACENT PAGE IS A TYPICAL CLOUD FORMATION PRESSURE PROFILE AS SUPPLIED BY THE UNIVERSITY OF MISSOURI.

CLOUD FORMATION PRESSURE PROFILE (UMR)



- PRESSURE CONTROL
  POSITIVE DISPLACEMENT
  WITH PRESSURE FEEDBACK

STATIC DIFFUSION LIQUID CHAMBER

(SDL)

SDL FEATURES

THE SDL DESIGN PROVIDES FOR THE CONTROL OF S_M TO LESS THAN 1% ERROR DOWN TO A S_M OF 0.2% AND TO LESS THAN 5% ERROR DOWN TO A S_M OF 0.01%. THE EXTERNAL/INTERNAL WATER RESERVOIR SYSTEM MAKES THE SDL INSENSITIVE TO LAUNCH FACTORS AND INDEPENDENT OF MISSION DURATION. NOMINAL OPERATING POWER ABOVE 0^oC IS 10 TO 20 WATTS.

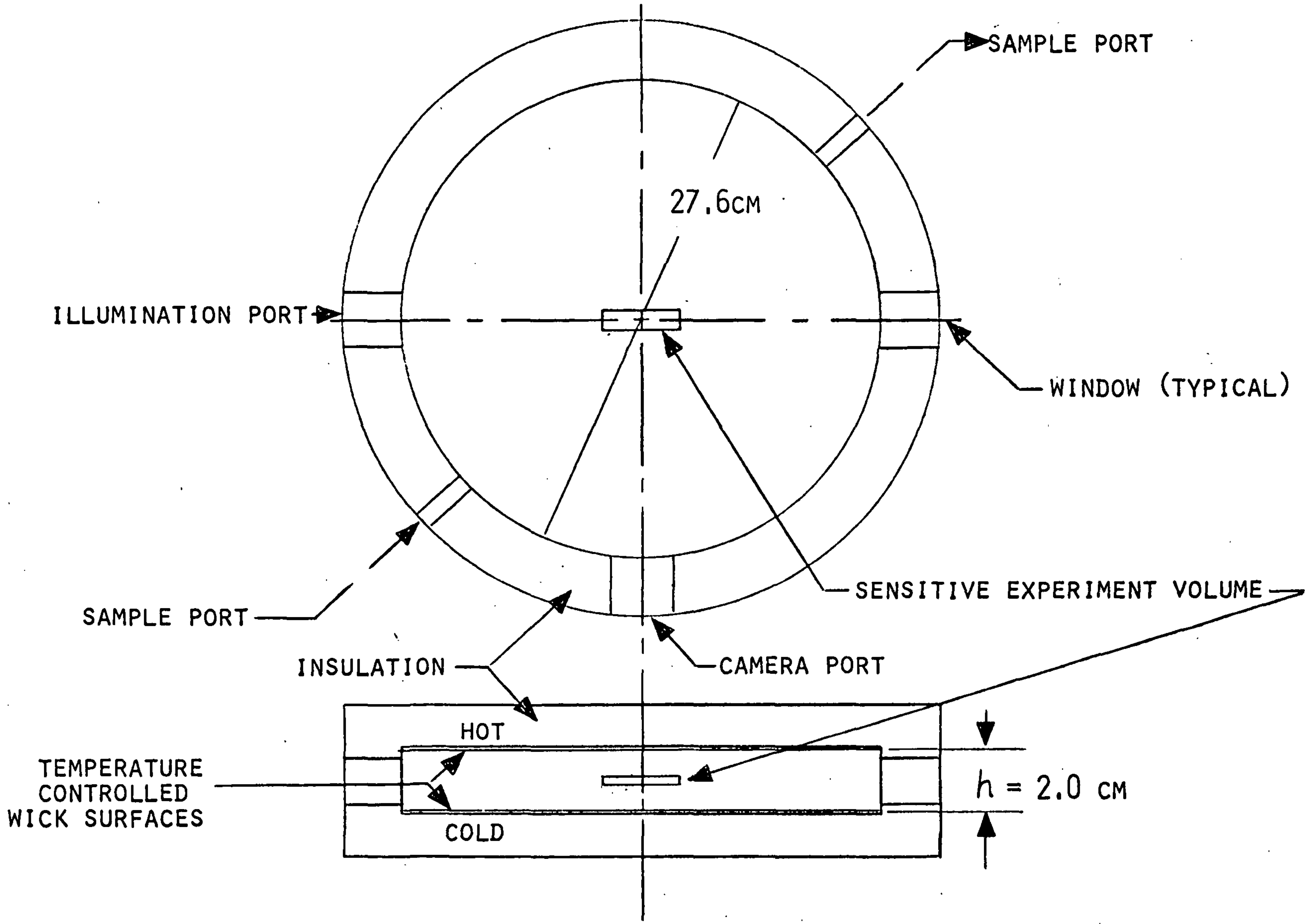
SDL FEATURES

- INTERNAL DIMENSIONS: DIAMETER 27.6 cm, PLATE SPACING 2 cm
- SENSITIVE EXPERIMENT VOLUME: 0.1 cm^3 (0.99 Sm), 0.17 cm^3 (0.97 Sm)
- ABSOLUTE TEMPERATURE CONTROLLED/MONITORED TO: $\leq 0.1^{\circ}C$
- RELATIVE PLATE TEMPERATURES CONTROLLED/MONITORED TO: $\leq 0.01^{\circ}C$
- SDL DIFFERENTIAL PLATE TEMPERATURE RATE OF CHANGE: $> 2^{\circ}C$ /MIN
- SEV ZONE TEMPERATURE FIXED FOR A SET OF S_m's
- RAPID EXPANSION CAPABILITY
- ALTERNATE DESIGN
  - INCREASED EFFECTIVE RESIDENCE TIME

SDL INTERNAL CONFIGURATION

THE OPTICS REQUIREMENTS ARE THE PRIME DRIVER FOR THE SDL CHAMBER. THE THERMAL AND VAPOR RELAXATION TIMES DETERMINE THE PLATE SPACING. MUCH OF THE SDL DESIGN ANALYSIS FOLLOWS FROM THE CFD DESIGN CONSIDERATIONS.

SDL CONFIGURATION

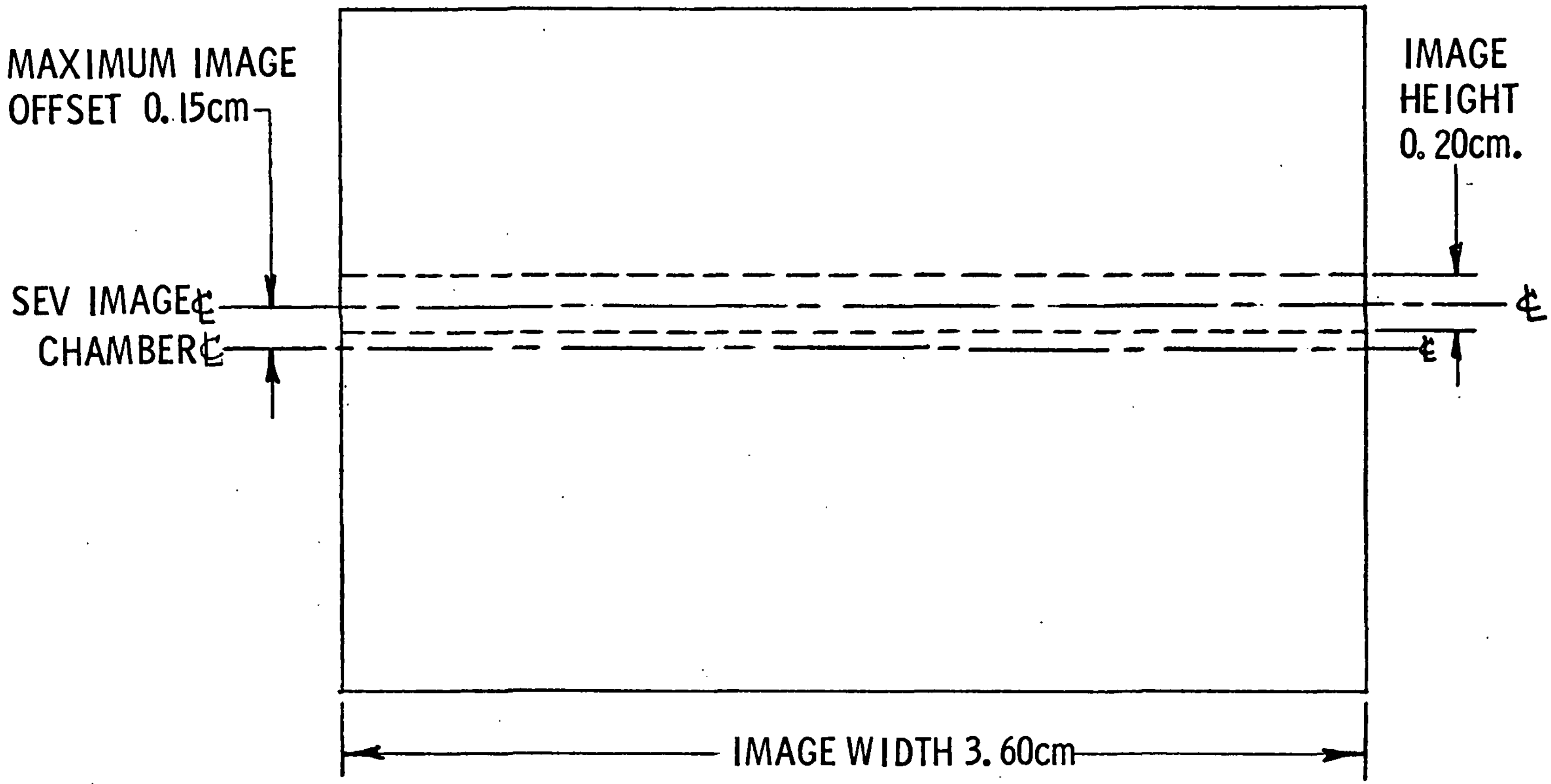


- SEV 0.20cm X 3.6cm X 0.139cm (0.99 S_m)

FILM IMAGE (SDL)

DUE TO THE ASYMMETRIC SUPERSATURATION FIELD, THE SENSITIVE EXPERIMENT VOLUME (SEV) IS DISPLACED TOWARD THE COLD PLATE. SINCE THIS OFFSET IS A FUNCTION OF S_M, THE CAMERA WILL BE SYMMETRICALLY LOCATED WITH APPROPRIATE LIGHT BEAM OFFSET TO ACCOMMODATE THE SEV.

FILM IMAGE (SDL)



FILM FORMAT 3.60 X 2.40cm

- o S_m LOCATED A MAXIMUM OF 0.15cm TOWARD COLD PLATE
- o DATA OUTSIDE 0.99 S_m AVAILABLE

HUMIDIFIER

45 —125

HUMIDIFIER FEATURES

THE HUMIDIFIER (SATURATOR) DESIGN LIMITS THE MIXING RATIO ERROR TO LESS THAN $\pm$ 0.1%. RELATIVE HUMIDITY AFTER THE REHEAT ZONE CAN BE CONTROLLED FROM LESS THAN 10% TO 100%. THE EXTERNAL/INTERNAL WATER RESERVOIR SYSTEM MAKES THE HUMIDIFIER (SATURATOR) INSENSITIVE TO LAUNCH FACTORS AND INDEPENDENT OF MISSION DURATION.

HUMIDIFIER FEATURES

- INTERNAL DIMENSIONS: WIDTH 20 cm, LENGTH 35.6 cm, PLATE SPACING 0.15 cm
- VOLUME FLOW RATE FOR 2 MODULES: 1000 cm^3/SEC
- SURFACE TEMPERATURES CONTROLLED/MONITORED TO:
  - HUMIDIFICATION AND TRANSITION ZONES $\pm 0.01^{o}C$
  - REHEAT ZONE $\pm 0.1^{o}C$
- SURFACE TEMPERATURE RANGES:
  - HUMIDIFICATION AND TRANSITION ZONES $-25^{o}C < T < 25^{o}C$
  - REHEAT ZONE $-22^{o}C < T < 75^{o}C$
- PRESSURE MONITORED/CONTROLLED TO: ± 1 mb
- PRESSURE RATE OF CHANGE: $\leq \pm 0.01$ mb/SEC
- AEROSOL CAN BE PASSED THROUGH HUMIDIFIER

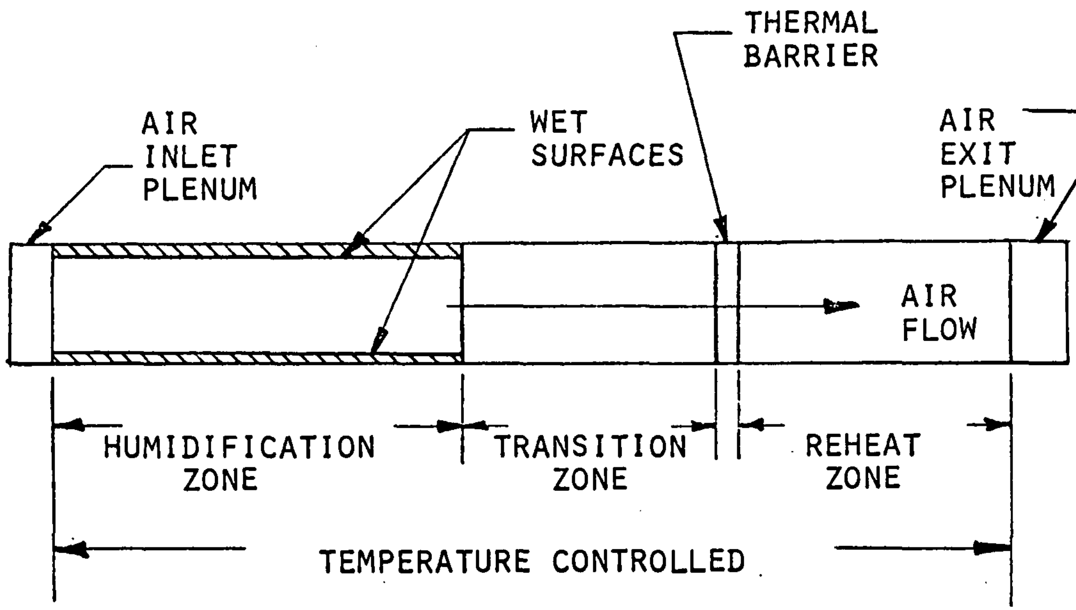
HUMIDIFIER INTERNAL DIMENSIONS

THE HUMIDIFIER (SATURATOR) ZONE LENGTHS ARE DETERMINED FROM DIFFUSION TIME CONSTANTS AND FLOW VELOCITIES. THE CROSS-SECTION AREA IS DETERMINED FROM CONSIDERATIONS OF THE ABOVE AND THE TOTAL AIR VOLUME THROUGHPUT. ADDITIONAL CONSIDERATIONS INCLUDE ACPL RACK DIMENSIONS AND AEROSOL LOSSESS (WHEN PASSED THROUGH THE HUMIDIFIER).

A TRANSITION ZONE PREVENTS THE REHEAT ZONE FROM INFLUENCING THE MIXING RATIO ESTABLISHED BY THE HUMIDIFICATION ZONE.

HUMIDIFIER INTERNAL DIMENSIONS

CROSS-SECTION



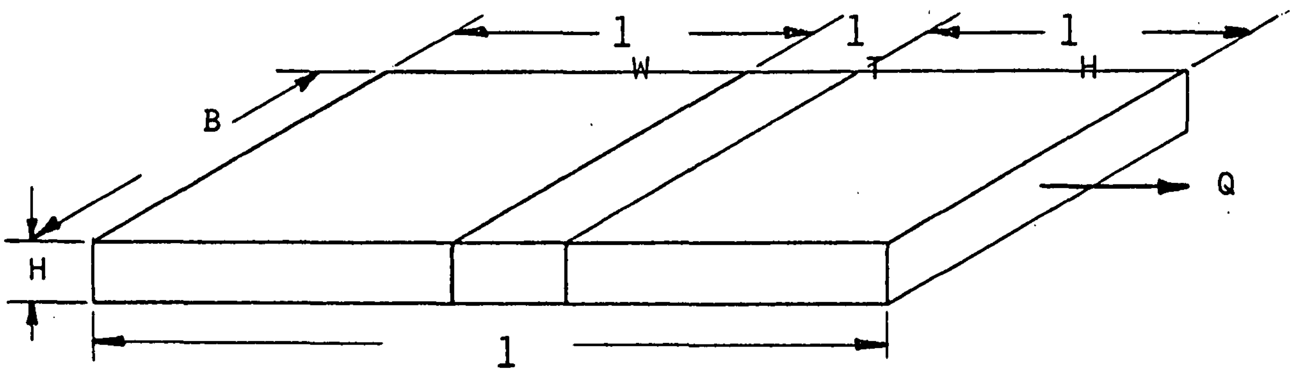
NOMENCLATURE

LENGTH

$l_W = 5.845\ QH/B$ (10 TIME CONSTANT)

$l_T = 0.22\ BH$ ($Q = 1\ cm^3/sec$)

$l_H = 3.454\ QHB$ (5 TIME CONSTANT)



PARTICLE DIFFUSION LOSS

$N/N_O = .9099$ EXP. $(-7.54\ LBK/HQ)$

AEROSOL GENERATOR

AEROSOL GENERATOR FEATURES

THE ATOMIZATION PLUS EVAPORATION/CONDENSATION DESIGN PROVIDES SHORT TERM STABILITY AND LONG TERM REPEATABILITY OF LESS THAN 3%. THE ATOMIZATION PORTION HAS SHOWN STABILITY VARIATIONS OF LESS THAN 1% IN TWENTY MINUTES. A SINGLE GENERATOR PROVIDES BOTH H_2SO_4 AND NACL.

AEROSOL GENERATOR FEATURES

METHOD	ATOMIZATION + EVAP/COND
MATERIAL	NaCL, H_2SO_4 (ANY SOLUBLE OR DISPERSABLE MATERIAL)
PARTICLE SIZE	3×10^{-3} μm TO >1 μm
QUANTITY	$<$ 2.5 mg/MIN ($<$ 1% SOLUTION)
CONCENTRATION	$< 10^{12}$ PARTICLES/cm^3
STABILITY	$\leq \pm 3\%$ LONG TERM $\leq \pm 1\%$ SHORT TERM (30 MINUTES)

AEROSOL GENERATOR CANDIDATES

A NUMBER OF APPROACHES ARE AVAILABLE FOR THE GENERATION OF NaCl AND H_2SO_4. SEVERAL OF THESE APPROACHES PROVIDE GOOD CONTROL ON THE AEROSOL GENERATION. THE ATOMIZER PLUS EVAPORATION/CONDENSATION PERMITS A SINGLE GENERATOR TYPE FOR BOTH NUCLEI GENERATION. BESIDES PROVIDING STABILITY AND REPEATABILITY, THIS GENERATOR IS COMPATIBLE WITH MANY SOLUBLE OR DISPERSIBLE MATERIALS.

AEROSOL GENERATOR CANDIDATES

NaCl GENERATORS

- HOT WIRE COATED WITH NaCl
- HOT TUBE WITH CERAMIC DISCS COATED WITH NaCl
- NaCl SOLUTION + ATOMIZER + E/C GEN. $\rightarrow$ NaCl

H_2SO_4 GENERATORS

- SO_2 + UV + H_2O $\rightarrow$ H_2SO_4
- SO_2 + CATALYST $\rightarrow$ H_2SO_4
- H_2SO_4 + ATOMIZER + E/C GEN $\rightarrow$ H_2SO_4

AEROSOL SAMPLE REPEATABILITY TRADE STUDY

THE ASSESSMENT OF THE AEROSOL VOLUME REQUIREMENTS OF THE EXPANSION CHAMBER RESULTS IN A PREFERENCE FOR CONTINUOUS,STABLE ON-LINE PRODUCTION OF AN AEROSOL. SUCH A GENERATOR IS AVAILABLE AND HAS BEEN SELECTED FOR THE INITIAL ACPL. THE SYSTEM DESIGN IS ALSO COMPATIBLE WITH AEROSOL STORAGE.

AEROSOL SAMPLE REPEATABILITY TRADE STUDY

SYSTEM DESIGN IMPACT ASSESSMENT-

REPEATABLE GENERATOR
- CONTINUOUS FLOW SYSTEM
- SOPHISTICATED GENERATOR DESIGN
- SIMPLIFIED FLUID SUBSYSTEM DESIGN

UNREPEATABLE GENERATOR
- "BATCH PROCESS" AEROSOL GENERATION
  - EXPERIMENT LIMITATIONS
- SIMPLE GENERATOR DESIGN
- SOPHISTICATED FLUID SUBSYSTEM DESIGN
  - STORAGE VOLUME
  - AGING VARIATIONS
  - FLOW START-UP/ SHUT-DOWN TRANSIENTS

TECHNOLOGY STATUS ASSESSMENT-

REPEATABLE AEROSOL GENERATION WITHIN "STATE-OF-THE-ART" CAPABILITY

ACPL DESIGN

REPEATABLE AEROSOL GENERATION WITH GROWTH ALLOWANCES FOR STORAGE AND AGING

AEROSOL CONDITIONERS

AEROSOL CONDITIONING CANDIDATES

A NUMBER OF METHODS ARE AVAILABLE TO SHAPE THE AEROSOL SIZE DISTRIBUTION. THE DIFFUSION BATTERY, ELECTROSTATIC CLASSIFIER AND FILTRATION UNIT ACT AS HIGH PASS AND BAND PASS FILTERS. THE DILUTER REDUCES THE PARTICLE CONCENTRATION, BOTH TO STOP COAGULATION AND TO ADJUST THE AEROSOL CONCENTRATION TO EXPERIMENT LEVELS. THE COAGULATOR (AN ON-LINE ITEM) AND THE STORAGE VOLUME (BATCH PROCESS APPROACH) BOTH MODIFY THE AEROSOL BY COAGULATION.

AEROSOL CONDITIONING CANDIDATES

- DILUTER
- COAGULATION TUBE
- DIFFUSION BATTERY
- PHOTO CHEMICAL CONDITIONER
- ELECTROSTATIC CLASSIFIER
- FILTRATION DEVICE
- STORAGE VOLUME (AGING)

AEROSOL CONDITIONING SELECTIONS

THE CONDITIONING UNITS BOTH COMPLEMENT AND OVERLAP THE FULL AEROSOL SPECTRUM SPECIFIED FOR THE INITIAL ACPL MISSIONS. THE OVERLAP PROVIDES BOTH FLEXIBILITY AND ALTERNATE VERIFICATION APPROACHES. HIGH PASS (LOW END CUT OFF) AND BAND PASS (MONODISPERSE) CAPABILITY ARE PROVIDED. THE DIFFUSION BATTERY AND ELECTROSTATIC CLASSIFIER ARE ALSO USED WITH THE CHARACTERIZERS TO PROVIDE AEROSOL SIZE DISTRIBUTIONS.

AEROSOL CONDITIONING SELECTIONS

SELECTED CONCEPTS

- ALL BUT FILTRATION AND STORAGE VOLUME RECOMMENDED ON INITIAL ACPL

FEATURES / CAPABILITY

- COMPLEMENTARY WITH OVERLAP
- COAGULATION TUBE - GROWS PARTICLES FROM 0.001 TO 0.1μm
- DIFFUSION BATTERY* - HIGH PASS FILTER 0.002 TO 0.1μm
- ELECTROSTATIC CLASSIFIER* - BAND PASS FILTER 0.01 TO 0.3μm
- DILUTER - ADJUSTS GENERATOR CONCENTRATION TO CHAMBER LEVELS
  - CONTROL COAGULATION RATE
- PHOTO-CHEMICAL CONDITIONER - DETECTS BACKGROUND CONTAMINANTS
- COMPLEMENT OF EQUIPMENT CONTRIBUTES TO MINIMIZING STORAGE REQUIREMENTS

* ALSO USED AS AEROSOL CHARACTERIZERS

AEROSOL CHARACTERIZERS

AEROSOL CHARACTERIZER CANDIDATES

THE FACING PAGE LISTS A NUMBER OF INSTRUMENTS WHICH ARE USED FOR CHARACTERIZATION OF PARTICLES FROM TEN MICROMETERS TO 10^{-3} MICROMETERS.

AEROSOL CHARACTERIZER CANDIDATES

• ELECTRICAL AEROSOL DETECTOR (EAD)	(0.01 - 5μm)
• CONDENSATION NUCLEI COUNTER (CNC)	(0.002 - 0.1μm)
• OPTICAL PARTICLE COUNTER (OPC)	(0.3 - 20μm)
• THERMAL PRECIPITATOR SAMPLER (TPS)	(0.002 - 1μm)
• ELECTROSTATIC AEROSOL SAMPLER (EAS)	(0.02 - 10μm)
• DIFFUSION BATTERY (DB) + CNC OR + EAD OR + CFD CHAMBER	(0.002 - 0.1μm)
• ELECTRICAL AEROSOL ANALYSER (EAA)	(0.003 - 1μm)
• ELECTROSTATIC CLASSIFIER (EC) + EAD OR + CNC OR + CFD CHAMBER	(0.01 - .3μm)

AEROSOL CHARACTERIZER SELECTION

THE INSTRUMENTS SELECTED FOR THE INITIAL ACPL PROVIDE COVERAGE FROM 10^{-3} μM TO 10 μM AND THEY ALSO PROVIDE SIZE DISTRIBUTION MEASUREMENTS IN ADDITION TO TOTAL PARTICLE COUNTS. THE INDICATED COMBINATIONS PROVIDE OPTIMUM SENSITIVITY AND ACCURACY USING THESE INSTRUMENTS. REAL TIME DISTRIBUTION (WITH MEASUREMENT OVERLAP CAPABILITY) AND A HARD COPY SAMPLE ARE PROVIDED.

AEROSOL CHARACTERIZERS SELECTION

SELECTED CONCEPTS

- DIFFUSION BATTERY* + CONDENSATION NUCLEI COUNTER
- ELECTROSTATIC CLASSIFIER* + ELECTRICAL AEROSOL DETECTOR
  + CONDENSATION NUCLEI COUNTER
- OPTICAL PARTICLE COUNTER
- THERMAL PRECIPITATOR SAMPLER

FEATURES/ CAPABILITY

- COMPLEMENTARY WITH OVERLAP; USED FOR TERRESTRIAL MEASUREMENTS
- THREE DETECTORS (CNC, EC/EAD, OPC) COVER RANGE FROM 0.002 TO 20μm
- DIFFUSION BATTERY AND ELECTROSTATIC CLASSIFIER ARE IMPORTANT CONDITIONERS ALSO
- CONTRIBUTES TO MINIMIZING STORAGE REQUIREMENTS
- ALL ARE COMMERCIALLY AVAILABLE

* ALSO USED AS AEROSOL CONDITIONERS

ACPL DESIGN/FUNCTIONAL FEATURES

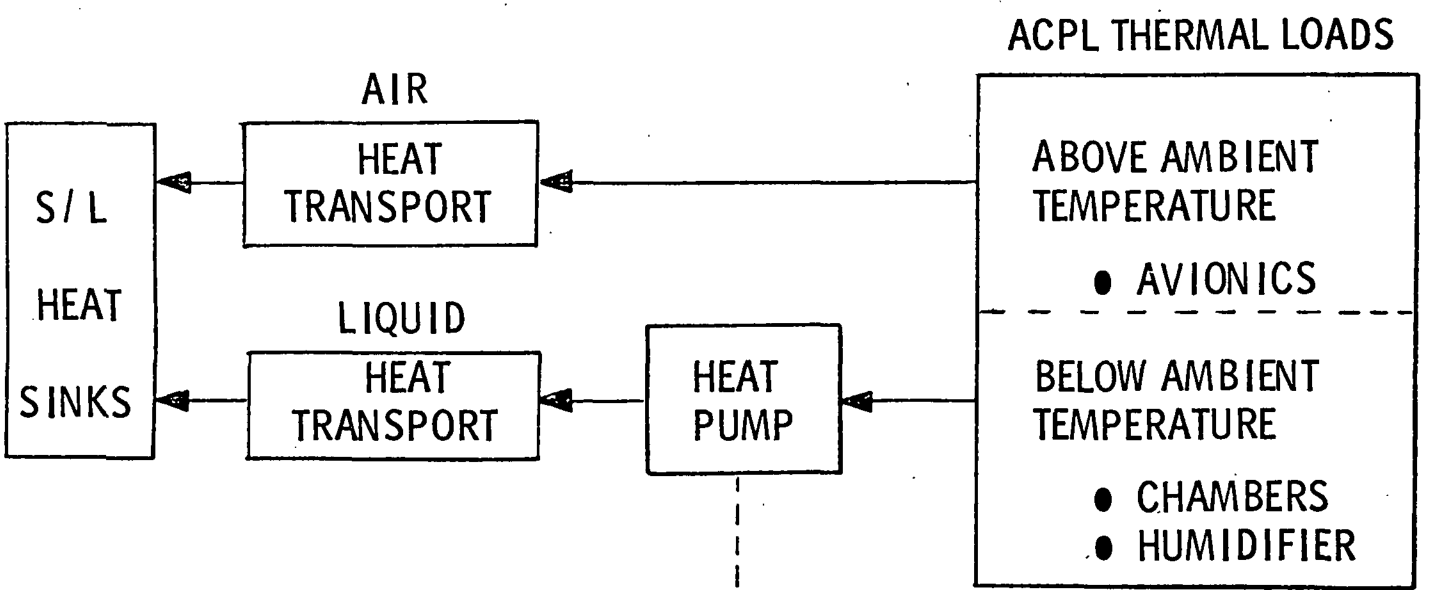
G. FOGAL

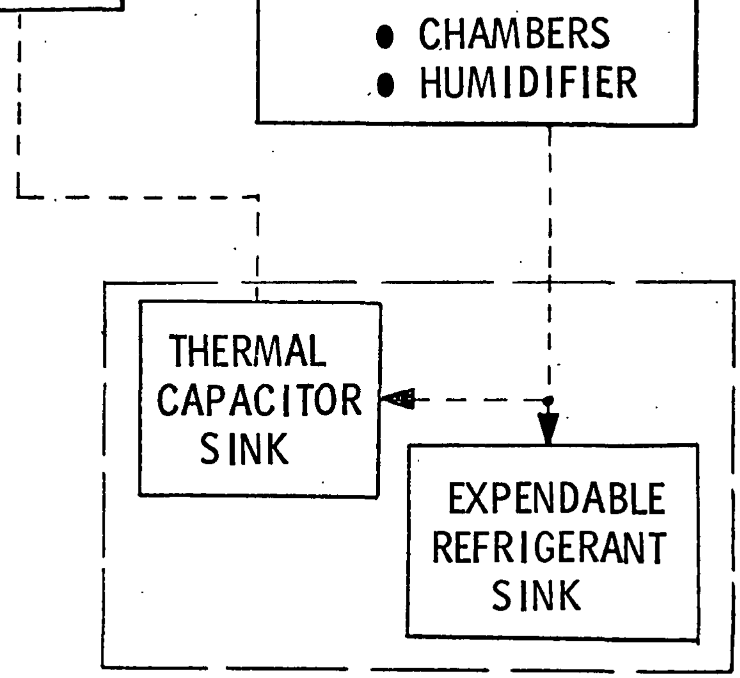
ACPL THERMAL CONTROL

THERMAL CONTROL

THE THERMAL CONTROL PROBLEM IS BASICALLY ONE OF COLLECTING THERMAL ENERGY FROM THE VARIOUS ACPL LOADS, TRANSPORTING THIS THERMAL ENERGY TO THE S/L HEAT SINK AND DISSIPATING THE ENERGY INTO THE S/L HEAT SINKS. TWO GENERAL TYPES OF ACPL THERMAL LOADS ARE EVIDENT, THE ABOVE AMBIENT TEMPERATURE AVIONICS THERMAL LOAD AND THE BELOW AMBIENT THERMAL LOADS REPRESENTED BY THE CLOUD CHAMBERS AND HUMIDIFIER. TO MINIMIZE PEAK POWER DURING RAPID CLOUD CHAMBER COOLDOWN, SUPPLEMENTAL LOW TEMPERATURE HEAT SINKS MAY BE REQUIRED. EXPENDABLE REFRIGERANTS AND THERMAL CAPACITORS ARE TWO EXAMPLES OF SUPPLEMENTARY SINKS WHICH MAY BE APPROPRIATE FOR ACPL.

ACPL THERMAL CONTROL





- MULTIPLE THERMAL LOADS
- LOAD VARIABLES
  - TEMPERATURE LEVEL
  - DISSIPATION RATE
  - CONTROL PRECISION
  - TRANSPORT MODE
- PEAK LOAD LIMITATION
  - SUPPLEMENTAL HEAT SINKS
    - REGENERABLE
    - EXPENDABLE

THERMAL CONTROL - EXPLORATORY ANALYSIS

THE RESULTS OF EXPLORATORY THERMAL ANALYSES FOR THE EXPANSION CHAMBER INDICATE THAT $\pm$ 0.01°C TEMPERATURE UNIFORMITY AND STABILITY CAN BE OBTAINED BUT THAT, FOR THE COMBINATIONS ANALYZED, THE RESULTING SUBSYSTEM POWER REQUIREMENT IS EXCESSIVE. RELAXING THE EXPANSION CHAMBER CONTROL REQUIREMENTS IS ONE APPROACH TO ATTAINING REASONABLE POWER INPUT. THE PREFERRED APPROACH IS TO INVESTIGATE REFINEMENTS AND ALTERNATE THERMAL CONTROL CONFIGURATIONS SUCH AS THE ADDITION OF THERMAL CAPACITORS AND THE REDUCTION OF SYSTEM THERMAL INERTIA.

EXPLORATORY ANALYSIS SUMMARY

ANALYSIS RESULTS

CANDIDATE CONTROL CONCEPT	S/S POWER	SURFACE TEMPERATURE UNIFORMITY
PUMPED COOLANT	6.5 KW	$\pm$ 0.02°C
PUMPED COOLANT/HEAT PIPE COMBINATION	4.1 KW	$\pm$ 0.01°C
TE HEAT PUMP	2.3 KW	$\pm$ 0.10°C
TE HEAT PUMP/HEAT PIPE COMBINATION	4.1 KW	$\pm$ 0.01°C

ASSESSMENT

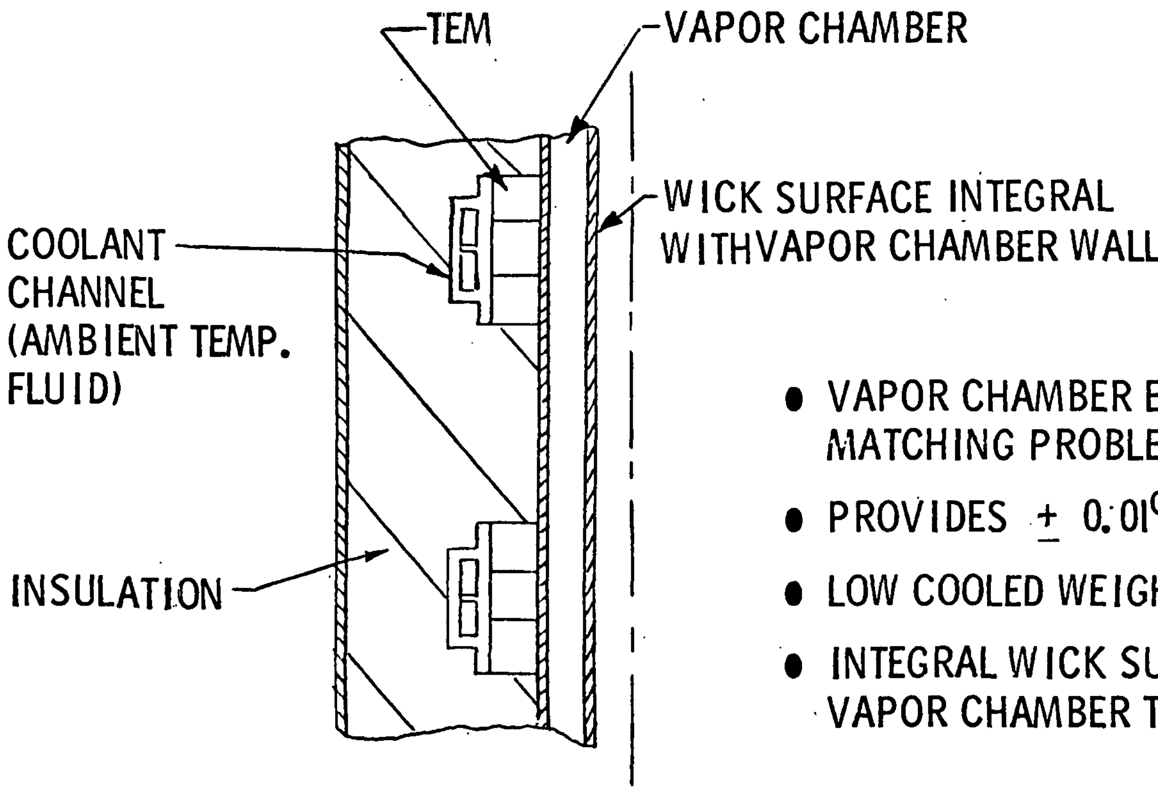
- S/S POWER EXCESSIVE
- SOLUTION

  RELAX SCIENTIFIC REQUIREMENTS
  INVESTIGATE ALTERNATE CONCEPTS
  ADD THERMAL CAPACITORS
  REDUCE THERMAL INERTIA

THERMAL CONTROL - WALL CONCEPT (CFD, SDL, HUMIDIFIER)

THE VAPOR CHAMBER APPROACH PROVIDES THE DESIRED CHAMBER TEMPERATURE UNIFORMITY AND STABILITY WHILE THE RELATIVELY LOW COOLED WEIGHT MINIMIZES POWER INPUT. THE "AVERAGING" EFFECT OF THE VAPOR CHAMBER ALSO ELIMINATES TEM MATCHING PROBLEMS.

WALL DESIGN CONCEPT, (CFD, SDL, AND HUMIDIFIER)



WALL SECTION

- VAPOR CHAMBER ELIMINATES TEM MATCHING PROBLEMS
- PROVIDES $\pm$ 0.01° C SURFACE TEMP. UNIFORMITY
- LOW COOLED WEIGHT MINIMIZES POWER REQUIRED
- INTEGRAL WICK SURFACE ELIMINATES WICK, VAPOR CHAMBER THERMAL COUPLING PROBLEMS

THERMAL CONTROL - CFD/SDL/HUMIDIFIER POWER ANALYSIS

AS SHOWN IN THE FACING PAGE TABLE, POWER REQUIREMENTS ARE MINIMAL FOR OPERATION OF THE CFD, SDL OR HUMIDIFIER AT $1^{o}C$.

CFD/SDL/HUMIDIFIER POWER ANALYSIS

EXAMPLE CONDITIONS

- OPERATION AT 1.0°C
- INITIAL TEMPERATURES, +25°C
- COOLDOWN AT 1°C/MIN.
- MAXIMUM AIR FLOW CONDITIONS (90% RH)
- TEMPERATURE UNIFORMITY/STABILITY AT OPERATING TEMPERATURE, $\pm$0.01°C

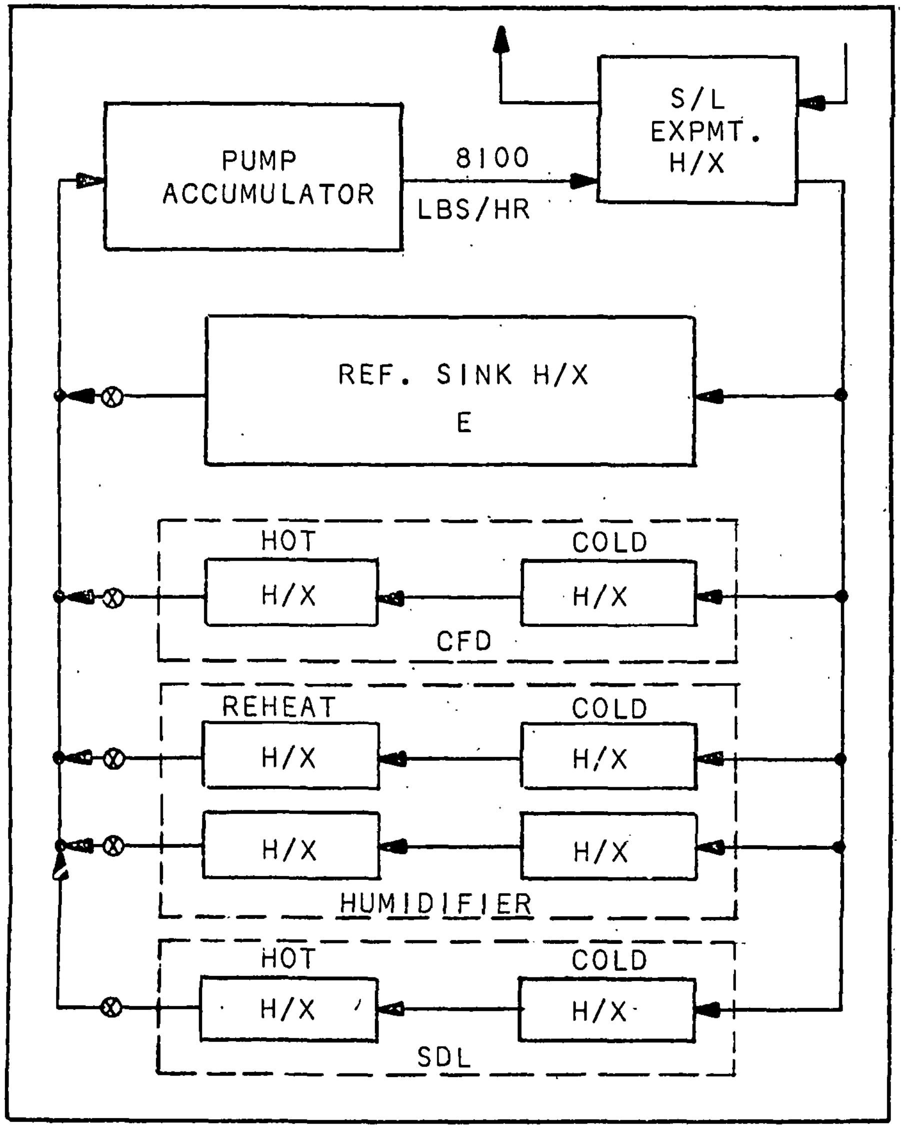
EQUIPMENT	WORSE CASE POWER USAGE*	
	PEAK POWER DURING COOLDOWN (WATTS)	STEADY STATE POWER AFTER COOLDOWN (WATTS)
CFD	146	20
SDL	78	13
HUMIDIFIER	76	26

* TEM PLUS PUMP POWER

THERMAL CONTROL - FLUID LOOP

AMBIENT TEMPERATURE OPERATION PERMITS USE OF WATER AS THE FLUID LOOP COOLANT. WATER IS NON-TOXIC, AN IMPORTANT CONSIDERATION FOR S/L USE, AND HAS THE BEST THERMAL AND FLUID FLOW PROPERTIES FOR THE ACPL APPLICATION. PUMP POWER AT MAXIMUM FLOW CONDITIONS IS ESTIMATED AT 35 WATTS (INCLUDING MOTOR AND PUMP INEFFICIENCIES).

THERMAL CONTROL FLUID LOOP



COOLANT

- FLOW RATE

E CHAMBER	6,000 LBS/ HR
CFD	900
SDL	600
HUMIDIFIER	600

- COUNTER-FLOW TYPE COOLANT CHANNELS 300 LBS/ HR/ CHANNEL TYPICAL
- TEMPERATURE : AMBIENT
- FLUID : WATER

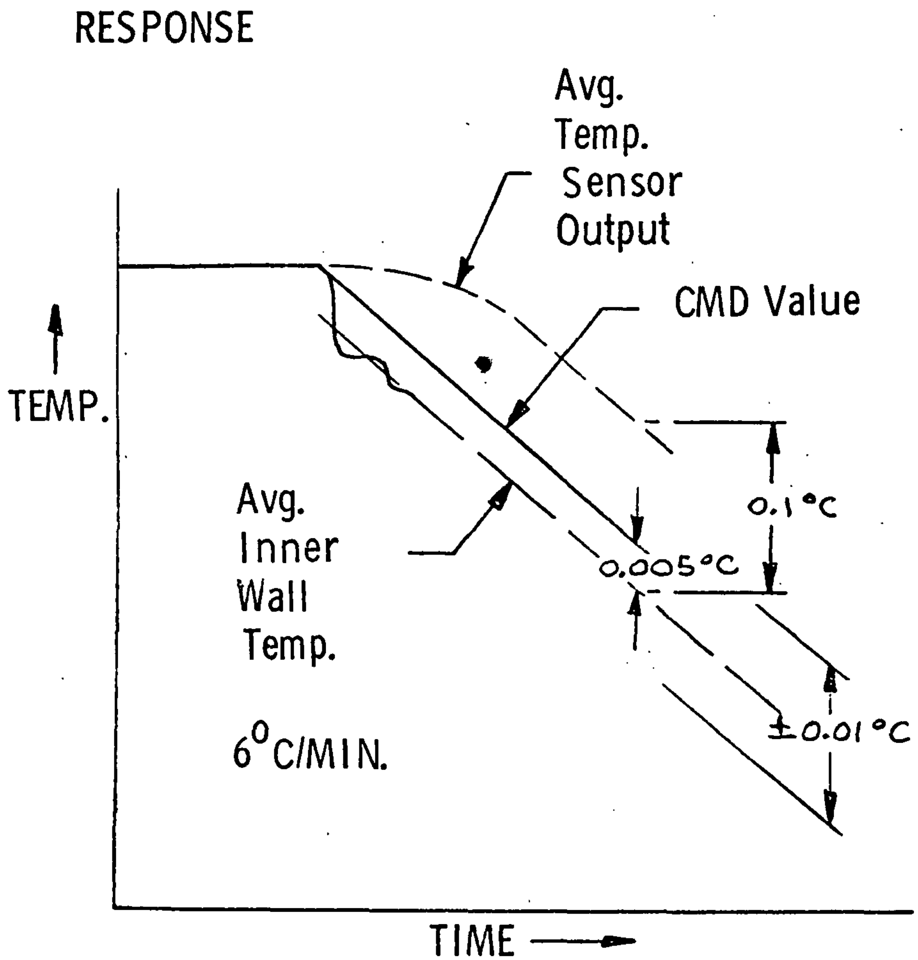
PUMP

- PRESSURE HEAD : 2 PSI
- POWER INPUT : 35 WATTS

THERMAL CONTROL - TEMPERATURE CONTROLLER RESPONSE

TEMPERATURE SENSOR LAG AND INNER WALL TEMPERATURE (CONTROLLED SURFACE) LEAD CAN BE MODIFIED BY CHANGES IN CONTROLLER CHARACTERISTICS AND SENSOR TIME CONSTANT.

TEMPERATURE CONTROLLER



- CONTROLLER CLOSED LOOP TIME CONSTANT, 2 SEC.
- TEMPERATURE SENSOR TIME CONSTANT, 1.0 SEC.

THERMAL CONTROL - SUMMARY

THE SELECTED THERMAL CONTROL APPROACHES SATISFY THE ACPL SCIENTIFIC REQUIREMENTS AND PROVIDE LOW POWER, FLEXIBLE OPERATION WITH GROWTH ACCOMMODATION.

THERMAL CONTROL SUMMARY

SELECTED DESIGN APPROACHES

- CLOUD CHAMBERS/HUMIDIFIER

  THERMAL ISOLATION
  VAPOR CHAMBER

- FLUID LOOP

  AMBIENT TEMPERATURE OPERATION

- CONTROLLER

  PROPORTIONAL
  STORED SENSOR CALIBRATIONS

SATISFY SCIENTIFIC REQUIREMENTS
IN COMBINATION WITH

- LOW POWER
- FLEXIBLE OPERATION
- GROWTH ACCOMMODATION

AIR CLEANING SUBSYSTEM

AIR CLEANING SUBSYSTEM - REQUIREMENTS

MAJOR DESIGN DRIVERS FOR THE AIR CLEANING SUBSYSTEM ARE MISSION LIFE AND INTERFACES WITH THE FLUID SUBSYSTEM.

AIR CLEANING SUBSYSTEM

REQUIREMENTS

- WATER VAPOR
  - $-0.5^{\circ}C$ DEW POINT
  - $-30^{\circ}C$ DEW POINT (10% LOAD FACTOR)
- CARBON DIOXIDE
  - 0.6% MAX
  - 0.03% MAX (10% LOAD FACTOR)
- ORGANICS/TRACE GASES
  - <0.1 PPM CARBON CONCENTRATION
- PARTICULATES
  - $<0.1/CM^3$ OVER 0.1 MICRON
  - $<100/CM^3$ AITKEN PARTICLES

MAJOR SUBSYSTEM DESIGN DRIVERS

- MISSION LIFE
- INTERFACE WITH FLUID SUBSYSTEM

AIR CLEANING SUBSYSTEM - CO_2 CONCENTRATION

AS SHOWN IN THIS SAMPLE ANALYSIS SUMMARY, RECIRCULATE FLOW IN THE FLUID SUBSYSTEM IS AN IMPORTANT FACTOR IN MINIMIZING WEIGHT OF THE AIR CLEANING SUBSYSTEM ELEMENTS. IN THE EXAMPLE SHOWN, LITHIUM HYDROXIDE WAS SELECTED BECAUSE OF ITS GREATER ADSORBTION EFFICIENCY AS WELL AS PROVEN PRIOR USE ON MANNED SPACECRAFT FOR CARBON DIOXIDE CONCENTRATION CONTROL.

AIR CLEANING SUBSYSTEM

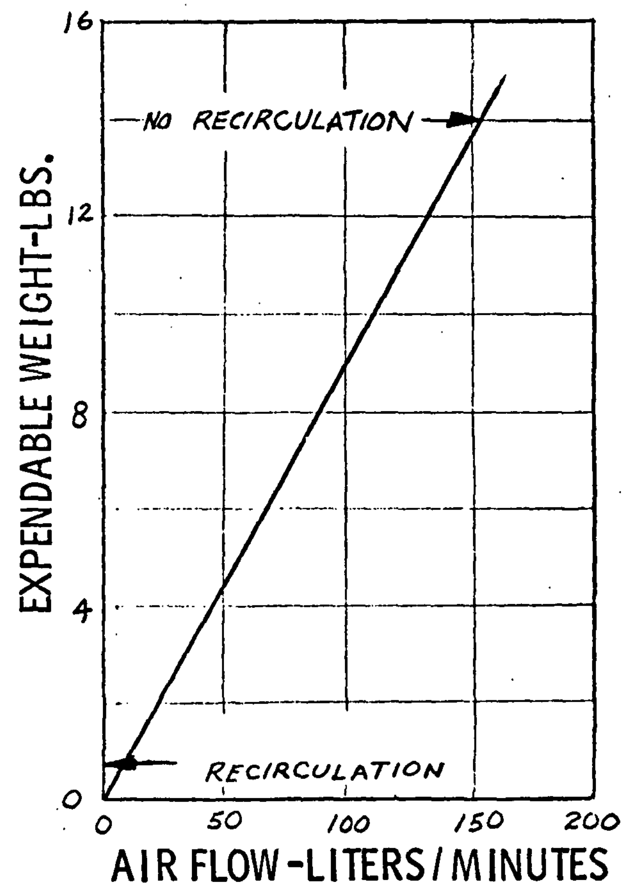
CARBON DIOXIDE CONCENTRATION

CONTROL CONCEPTS

- REGENERABLE SORBENTS
  - POWER PENALTY
- EXPENDABLE ADSORBENT
  - MOLECULAR SIEVE
  - LITHIUM HYDROXIDE

SELECTED CONCEPT

- LITHIUM HYDROXIDE
  - MAXIMUM CAPACITY (LB/LB AIR)
- RECIRCULATE FLOW
  - 0.75 LBS/MISSION
    - 0.03% MAX. CONCENTRATION
- REPLACE BEFORE EACH MISSION



AIR CLEANING SUBSYSTEM - SUMMARY

THE AIR CLEANING SUBSYSTEM SATISFIES THE ACPL SCIENTIFIC REQUIREMENTS FOR CONTAMINATE CONTROL. THE SYSTEM DESIGN FEATURES PASSIVE APPROACHES WITH RECIRCULATE FLOW THE KEY TO MINIMIZING SUBSYSTEM SIZE AND WEIGHT.

AIR CLEANING SUBSYSTEM

SUMMARY

- SATISFIES SCIENTIFIC REQUIREMENTS
- PASSIVE CONTROL SELECTED
- MINIMUM EXPENDABLES VIA RECIRCULATE FLOW
- STATE OF THE ART APPROACH
- SUBSYSTEM WEIGHT

HARDWARE:	12.2 LBS.
EXPENDABLES:	27.8
	40.0 LBS.

FLUID SUBSYSTEM

FLUID SUBSYSTEM - REQUIREMENTS

SUBSYSTEM DESIGN DRIVERS ARE THE RELATIVELY LARGE NUMBER OF POINTS IN ACPL SYSTEM WHERE FLOW MUST BE CONTROLLED, THE FLOW RANGE AND INTERFACING WITH THE AIR CLEANING SUBSYSTEM IN SUCH A WAY AS TO MINIMIZE WEIGHT OF EXPENDABLES, I.E., THE USE OF RECIRCULATE FLOW PATHS.

FLUID SUBSYSTEM

REQUIREMENTS

- AIR/AEROSOL CIRCULATION THRU ACPL
- FLOW
  - ADJUSTABLE SETTINGS TO MATCH EXPERIMENT REQUIREMENTS
  - MAINTAIN WITHIN $\pm 1.0\%$ OF SET VALUE
  - MONITOR
- PRESSURE
  - MAXIMUM RATE OF CHANGE 0.01 MB/SECOND
    - HUMIDIFIER AND CFD
  - OPERATION NEAR S/C AMBIENT
  - MONITOR

MAJOR SUBSYSTEM DESIGN DRIVERS

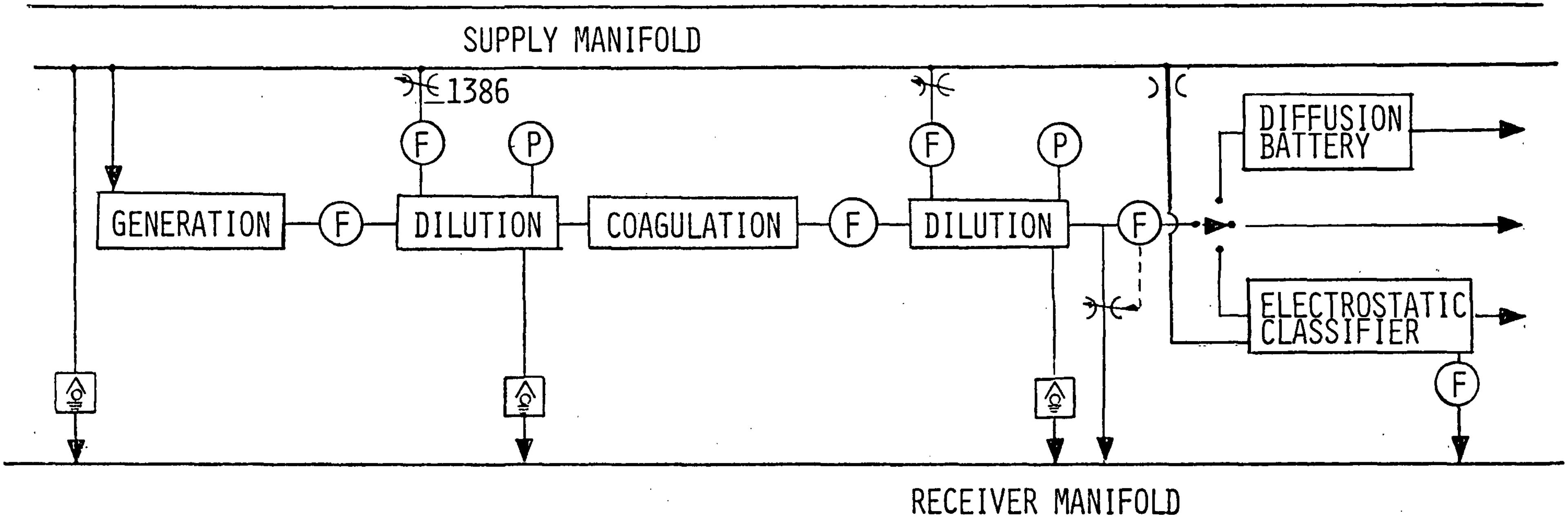
- NUMBER OF FLOW CONTROL POINTS (30)
- CONTROLLED FLOW RANGE (2 - 1680 CM^3/SECOND)
- INTERFACE WITH AIR CLEANING SUBSYSTEM
  - WEIGHT OF EXPENDABLES

FLUID SYSTEM - FLOW CONTROL CONCEPT

FLOW CONTROL IS ACHIEVED BY A COMBINATION OF DIFFERENTIAL PRESSURE CONTROL AND FLOW SENSOR FEEDBACK. FLOW AND PRESSURE MONITORS ARE ALSO PROVIDED FOR OBTAINING EXPERIMENT AND HOUSE-KEEPING DATA.

FLUID SUBSYSTEM

FLOW CONTROL CONCEPT



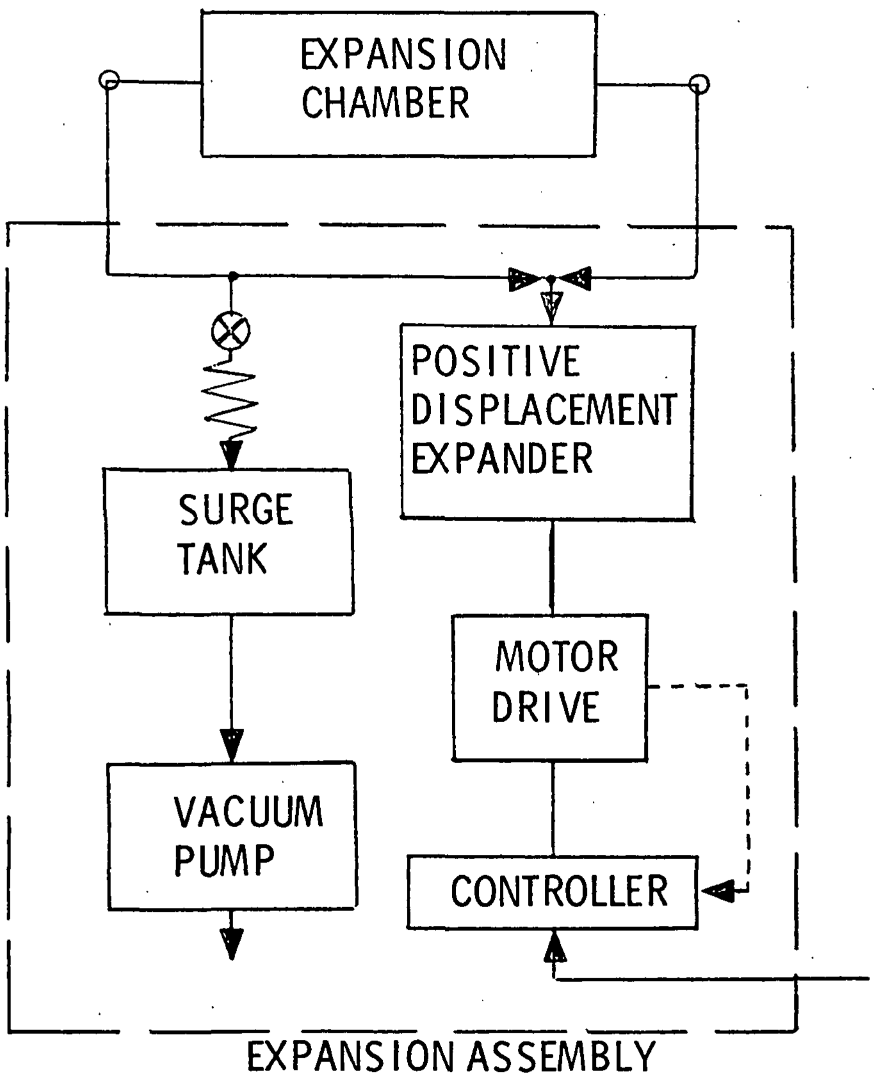
COMBINATION

- DIFFERENTIAL PRESSURE CONTROL
  - PRESSURE RELIEF VALUES
  - INCREMENTAL FLOW SETTINGS
- FLOW SENSOR FEEDBACK
  - MAINTAIN CALIBRATION FLOWS
- FLOW/ PRESSURE MONITORS
  - EXPERIMENT/ HOUSEKEEPING DATA

FLUID SUBSYSTEM - EXPANDER ASSEMBLY CONCEPT

THE PRIMARY FUNCTION OF THE EXPANDER ASSEMBLY IS TO PROVIDE PRECISION EXPANSION IN THE EXPANSION CHAMBER TO A PREPROGRAMMED PRESSURE/TIME PROFILE. A SECONDARY FUNCTION IS TO EVACUATE THE EXPANSION CHAMBER TO AN INITIAL STARTING PRESSURE (FOR THE PRECISION EXPANSION).

EXPANDER ASSEMBLY EXPANSION CONCEPT



PRECISION EXPANSION MODE

- POSITIVE DISPLACEMENT
- CONTROLLED RATE
- REVERSIBLE

INITIALIZATION EXPANSION MODE

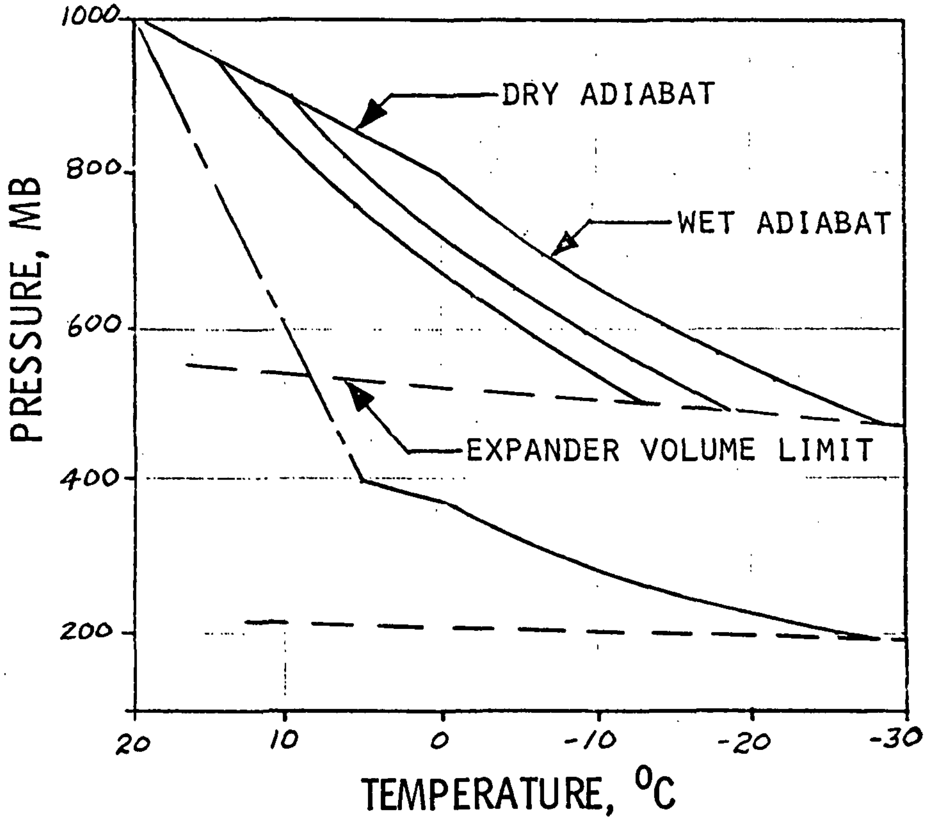
- EVACUATE TO EXPERIMENT INITIAL PRESSURE
- EVACUATION RATE
  - FIXED ORIFICE CONTROL
  - RATE LIMITED BY E-CHAMBER AIR THERMAL TIME CONSTANT
- ALTERNATE
  - VENT TO SPACE VACUUM

E CHAMBER PRESSURE/TEMPERATURE

AN ADIABATIC EXPANSION CAN BE INITIATED FROM INITIAL PRESSURES BETWEEN 1013 AND 400 MB WITH PRECISION EXPANSION PRESSURE CHANGES OF UP TO 500 MB. INITIAL PRESSURES AND CORRESPONDING EXPANSIONS BELOW 400 MB CAN BE ACCOMMODATED. THE ADJACENT PAGE ILLUSTRATES EXAMPLES OF SEVERAL PRESSURE PROFILES.

EXPANDER ASSEMBLY

E-CHAMBER (30.6L)



FUNCTION

- PROVIDE PRECISION EXPANSION
  PRECALCULATED PRESSURE, TIME
  PROFILE

EXPANSION RANGE

- PRESSURE
  1013 TO 400 MB
- TEMPERATURE
  +20 TO -25° C

DESIGN DRIVERS

- EXPANDER VOLUME
  24 L SELECTED
- PRECISION CONTROL
- EXPANSION RANGE
  2 EXPANSIONS

CONTROL AND DATA SUBSYSTEM

CONTROL AND DATA SUBSYSTEM - DESIGN APPROACH

THE CANDIDATE CONFIGURATIONS SELECTED ARE IN THREE CATEGORIES: (1) ALL DATA PROCESSING AND CONTROL FOR ACPL ACCOMPLISHED VIA THE S/L COMPUTER, (2) ALL PROCESSING AND CONTROL INTEGRAL TO THE ACPL AND (3) COMBINATIONS OF THE ABOVE. THE FIRST TWO CATEGORIES REPRESENT EXTREME CONDITIONS WHICH SERVE TO BOUND THE ANALYSIS EFFORT.

CONTROL AND DATA SUBSYSTEM

DESIGN APPROACH

- AUTOMATIC WITH MANUAL OVERRIDE VIA S/L KEYBOARD

CANDIDATE CONFIGURATIONS

- ALL PROCESSING/CONTROL VIA S/L COMPUTER
- ALL PROCESSING/CONTROL WITHIN ACPL
- COMBINATION

MAJOR DESIGN DRIVERS

- COMPUTER LOADING

    DATA MONITORING
    COMMAND INITIATION
    COMPUTATION/DATA PROCESSING

- SOFTWARE REQUIREMENTS
- S/L HARDWARE CAPABILITY/AVAILABILITY
- COST

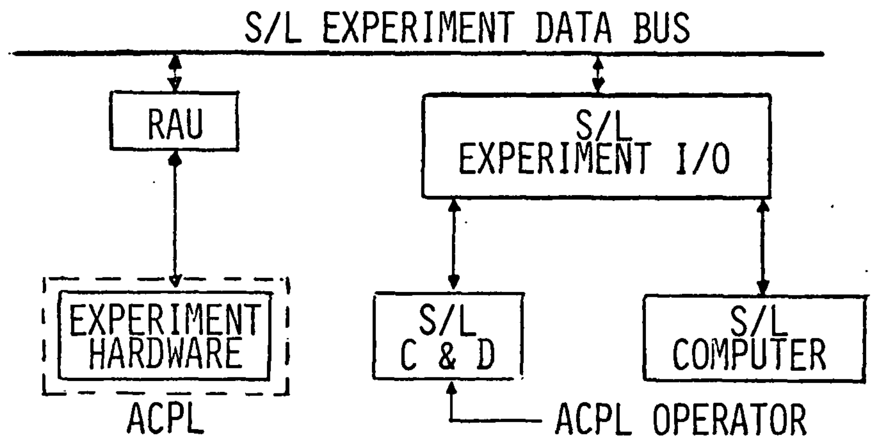
CONTROL AND DATA SUBSYSTEM - CANDIDATE SUBSYSTEMS

THIS CHART DEFINES THE THREE CANDIDATE CONFIGURATIONS. NOTE THAT THE OPERATOR INTERFACE LOCATION IS DIFFERENT FOR EACH OF THE CANDIDATE CONFIGURATIONS.

CANDIDATE CONFIGURATIONS

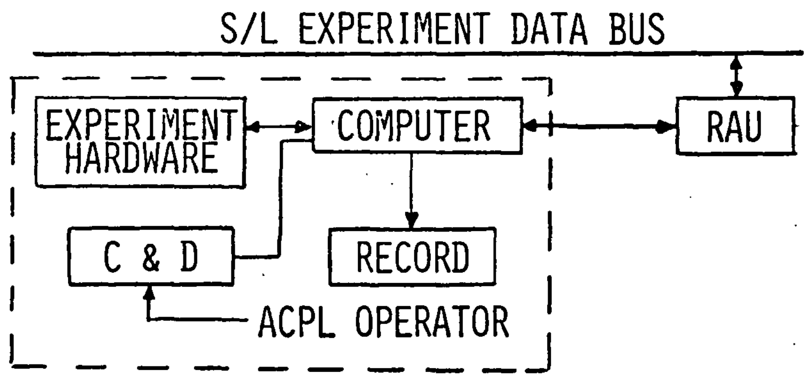
PROCESSING/CONTROL VIA S/L CDMS

- DEPENDENT ON S/L EQUIPMENT
  - COMPUTER
  - C&D
  - RECORDING
- SENSITIVE TO OTHER EXPERIMENT REQUIREMENTS
- MINIMUM ACPL HARDWARE



PROCESSING/CONTROL WITHIN ACPL

- INDEPENDENT OF S/L
- INSENSITIVE TO OTHER EXPERIMENT REQUIREMENTS
- MAXIMUM ACPL HARDWARE



HYBRID

- MINI-COMPUTER/MICRO-PROCESSOR IN ACPL
  - MINIMUM ACPL LOAD ON S/L COMPUTER

CONTROL AND DATA SUBSYSTEM - SUMMARY

PROCESSING AND CONTROL VIA THE S/L COMPUTER HAS BEEN TENTATIVELY SELECTED FOR THE BASELINE ACPL CONTINGENT ON THE COMPLETION OF THE SOFTWARE COST ANALYSIS.

CONTROL AND DATA SUBSYSTEM

SUMMARY

- AUTOMATIC ACPL OPERATION

  COMMAND INPUTS
  DATA MONITORING
  DATA DISPLAY VIA S/L CRT

- OPERATOR INTERFACE

  VIA S/L KEYBOARD
  CHANGE EXPERIMENT PARAMETERS
  MONITOR EXPERIMENT/HOUSEKEEPING DATA
  E CHAMBER TEMPERATURE/PRESSURE PROFILE SELECTION

- PROCESSING/CONTROL VIA S/L COMPUTER

  PRELIMINARY BASELINE SELECTION
  MINIMAL COMPUTER LOAD
  SOFTWARE ANALYSIS IN PROCESS
  NO ACPL HARDWARE REQUIRED

POWER CONDITIONING/DISTRIBUTION

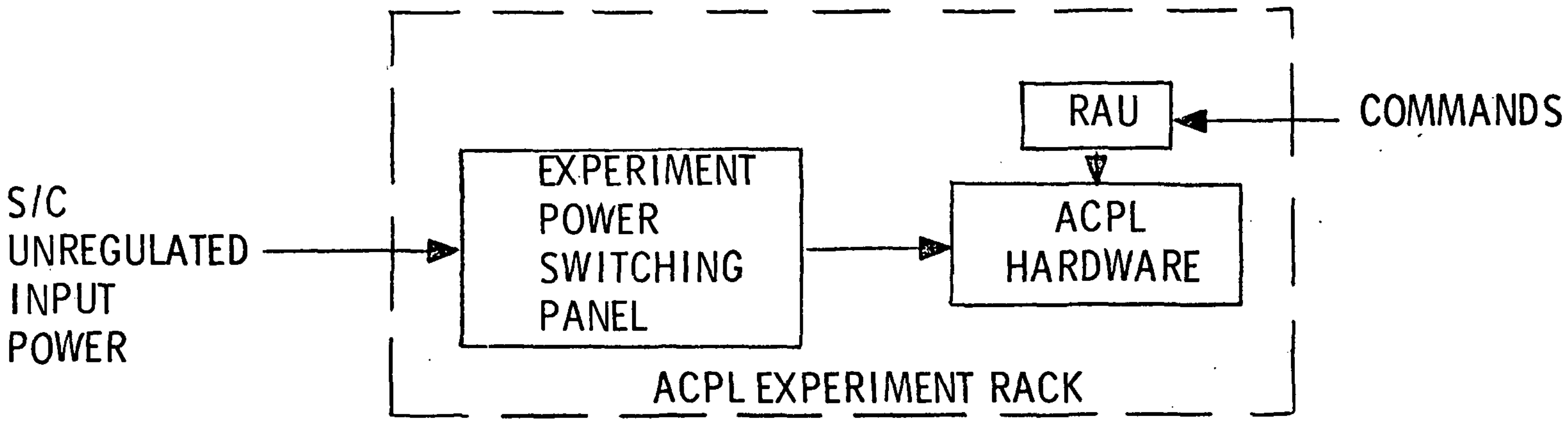
GSE/STE

ACPL CONFIGURATION

POWER CONDITIONING/DISTRIBUTION

FOR THE BASELINE DESIGN, EACH MAJOR EQUIPMENT ITEM IS ASSUMED TO INCLUDE THE REQUIRED POWER CONDITIONING CAPABILITY REQUIRED. THIS APPROACH PROVIDES MAXIMUM SYSTEM/EQUIPMENT DESIGN FLEXIBILITY. CAPACITY, VOLTAGE LEVELS, REGULATION CAN THUS BE TAILORED TO THE SPECIFIC REQUIREMENTS OF EACH MAJOR EQUIPMENT ITEM.

POWER CONDITIONING/DISTRIBUTION



UNREGULATED POWER

- DIRECT TO SPECIFIC ACPL EQUIPMENTS FROM EXPERIMENT POWER SWITCHING PANEL

REGULATED POWER

- CONDITIONERS PROVIDED WITH EACH ACPL EQUIPMENT; OUTPUT CAPACITY/VOLTAGE LEVEL AS REQUIRED

  INCLUDED IN COMMERCIALLY DERIVED EQUIPMENTS
  CAPACITY/VOLTAGE LEVELS/REGULATION TAILORED TO SPECIFIC EQUIPMENT REQUIREMENTS
  MAXIMUM SYSTEM/EQUIPMENT DESIGN FLEXIBILITY
    EQUIPMENT REDESIGN
    FUTURE GROWTH

ON-OFF CONTROL/OVERLOAD PROTECTION

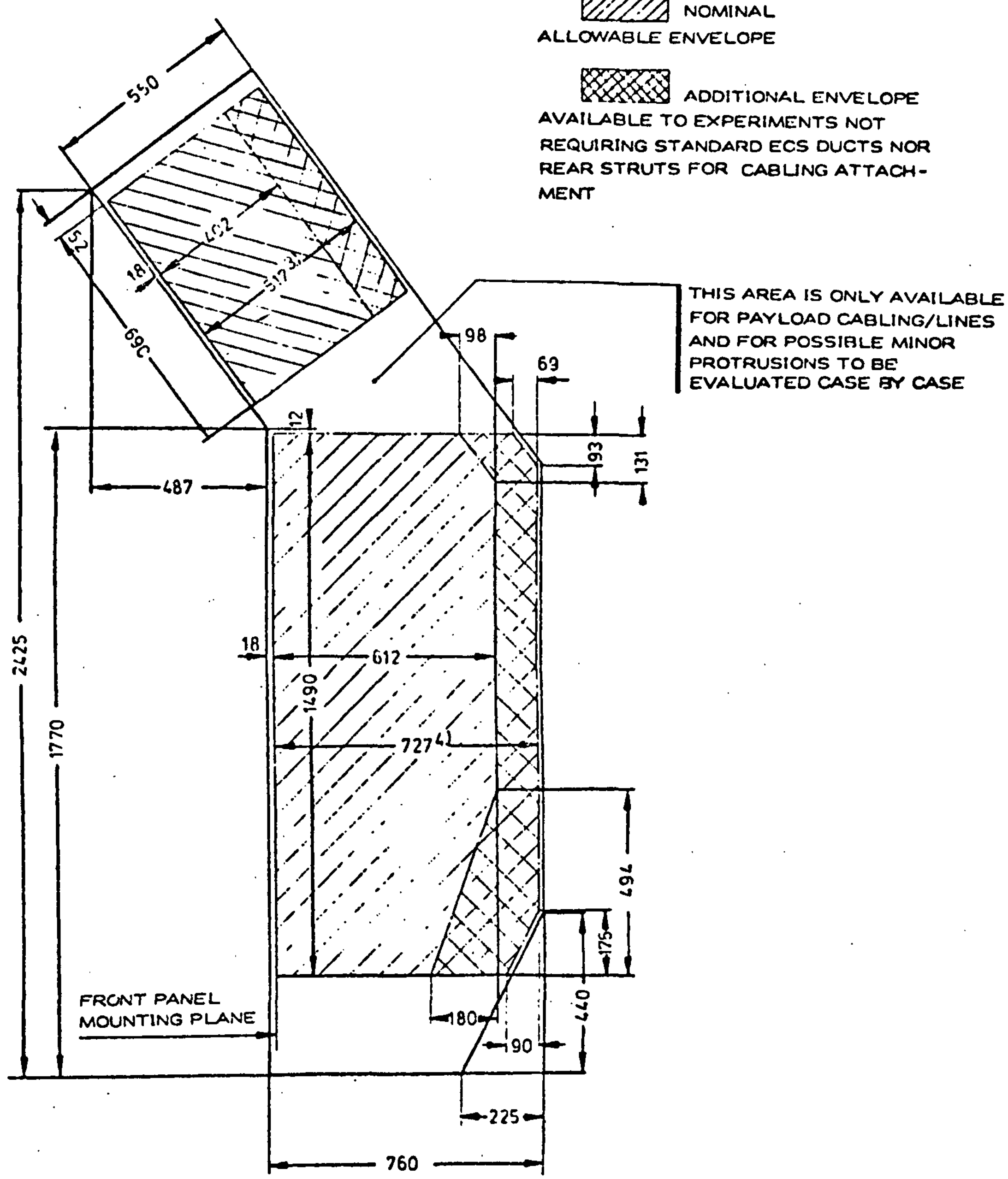
- PROVIDED BY EXPERIMENT POWER SWITCHING PANEL

ACPL CONFIGURATION - RACK VOLUME

AS SHOWN, THE MAXIMUM AVAILABLE VOLUME FOR INSTALLATION OF THE ACPL IS 1500 LITERS. THIS VOLUME APPEARS MORE THAN SUFFICIENT FOR THE INITIAL ACPL SYSTEM.

ACPL CONFIGURATION

- TOTAL RACK VOLUME
  2028 LITERS
- MAXIMUM TOTAL AVAILABLE FOR EXPERIMENT HARDWARE
  1500 LITERS



-265

POWER CONDITIONING/DISTRIBUTION, GSE/STE, ACPL CONFIGURATION - SUMMARY

A FIRST CUT INSTALLATION OF THE BASELINE INITIAL ACPL SYSTEM HAS BEEN COMPLETED; WEIGHT AND VOLUME ARE WITHIN THE EXPERIMENT RACK LIMITS.

POWER CONDITIONING/ DISTRIBUTION
GSE/ STE
ACPL CONFIGURATION

SUMMARY

- POWER CONDITIONING/ DISTRIBUTION
  - UNREGULATED POWER TO INDIVIDUAL EQUIPMENTS
  - CONDITIONING INTERNAL TO EQUIPMENT
    - MAXIMUM SYSTEM/ EQUIPMENT DESIGN FLEXIBILITY

- GSE/ STE
  - PRELIMINARY IDENTIFICATION COMPLETED

- CONFIGURATION
  - FIRST CUT INSTALLATION LAYOUT COMPLETED
  - INITIAL ACPL CONFIGURATION WITHIN CONSOLE
    - WEIGHT/ VOLUME LIMITATIONS

PROGRAMMATICS

R. BIRMAN

123 - 273

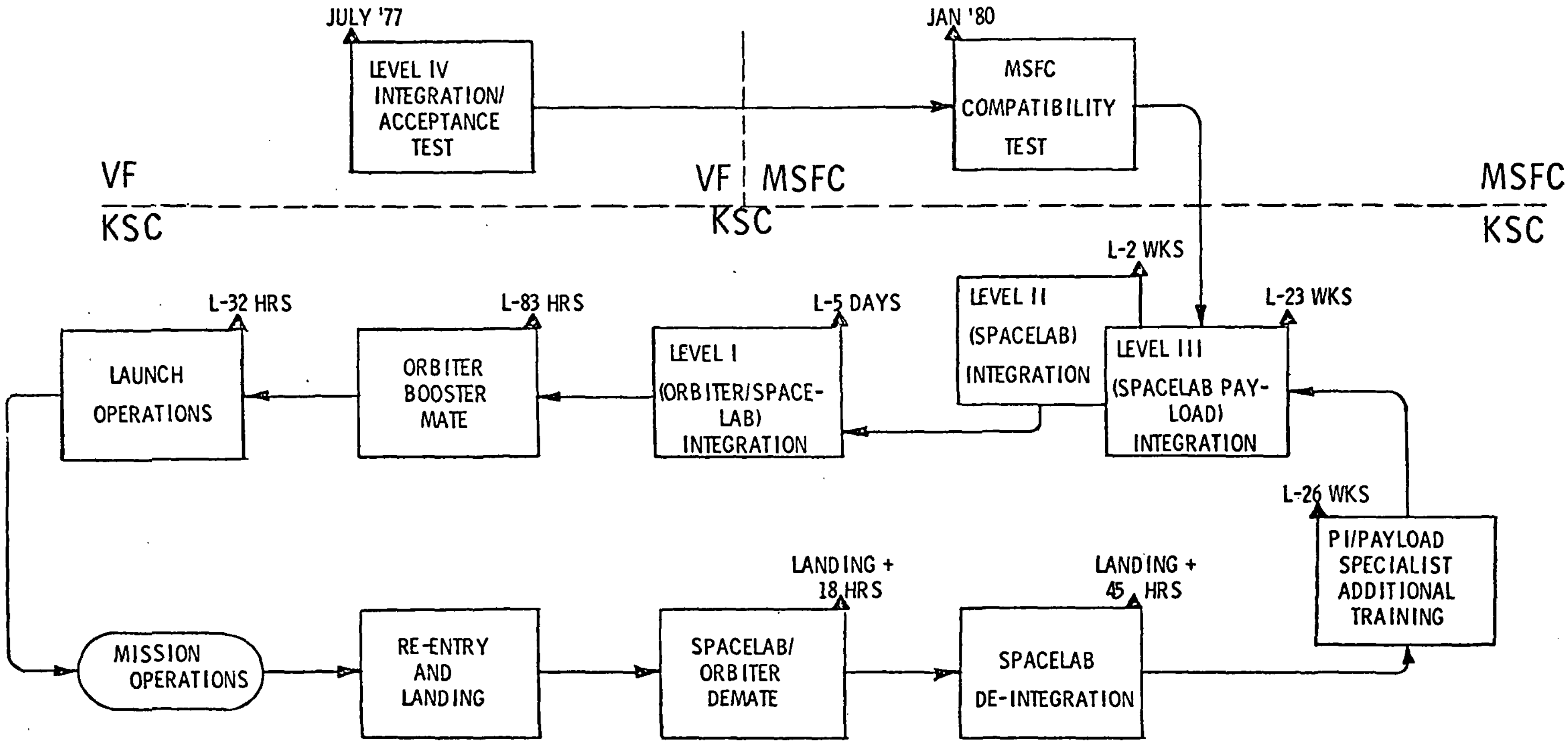
OPERATIONS - P274
ACPL DELIVERY PLAN - 275
ACPL DELIVERY PLAN DRIVERS - 276

OPERATIONS

ACPL OPERATIONS S/L #1 - S/L #3

THE ACPL OPERATIONS CYCLE IS SHOWN STARTING AT GENERAL ELECTRIC-VALLEY FORGE, PROCEEDING TO MSFC FOR COMPATABILITY CHECKS AND ON TO KSC FOR MISSION OPS, AND TERMINATING AT THE SPACELAB PROCESSING FACILITY FOR MISSION #1. SPACELAB 3 ACPL CYCLE STARTS AND FINISHES AT THE KSC-SPF FACILITY.

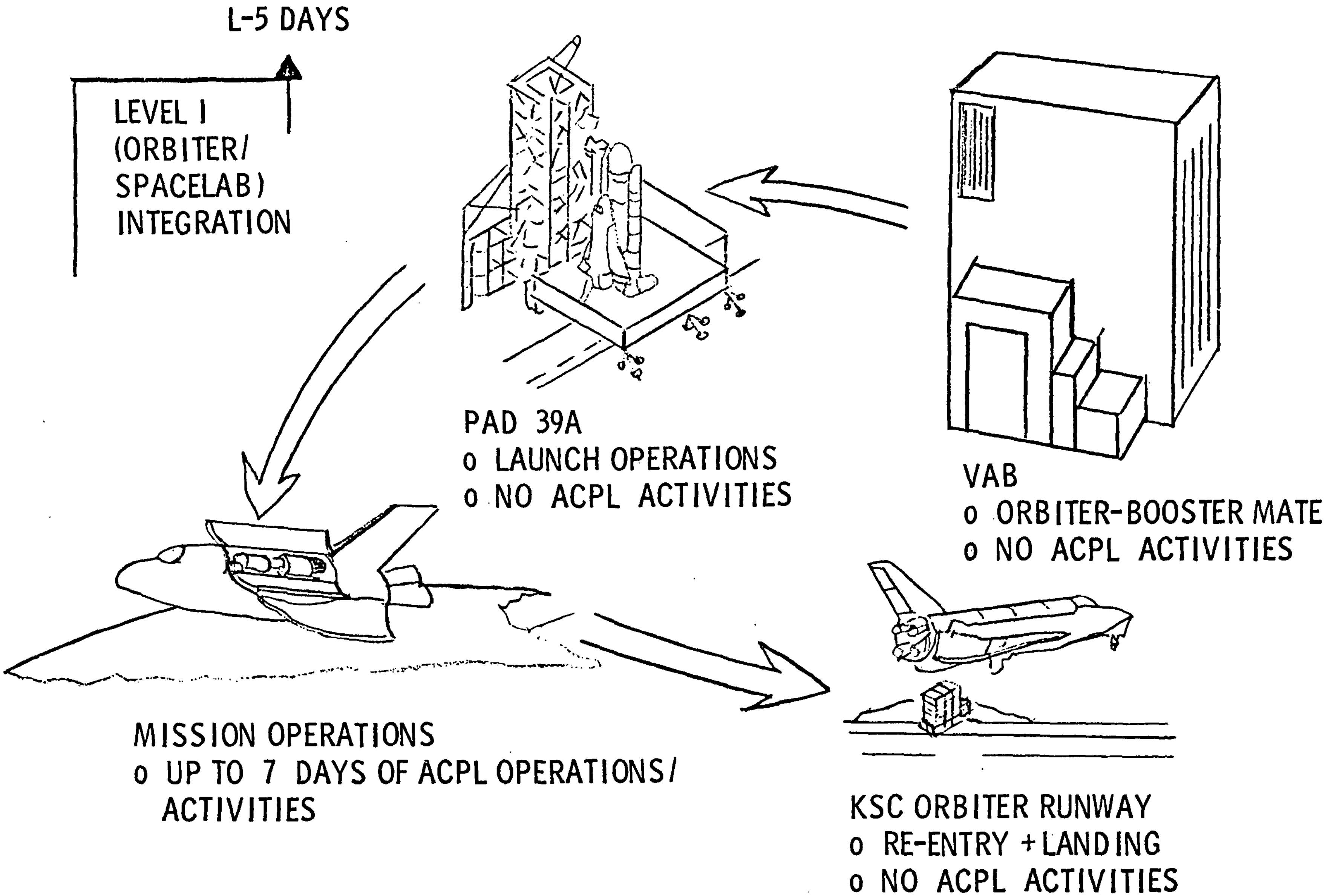
ACPL OPERATIONS S/L #1 - S/L #3



ORBITER-BOOSTER MATE TO RE-ENTRY AND LANDING

THIS SEQUENCE OF EVENTS REQUIRES APPROXIMATELY 83 HOURS FOR ORBITER-BOOSTER MATE, AND PAD OPERATIONS PLUS 7 DAYS OF MISSION TIME. NO PROBLEMS ARE NOTED WITH THE SCHEDULE OF ACTIVITY. NO ACPL PLANNED ACTIVITY EXIST DURING THE ON-GROUND PHASES.

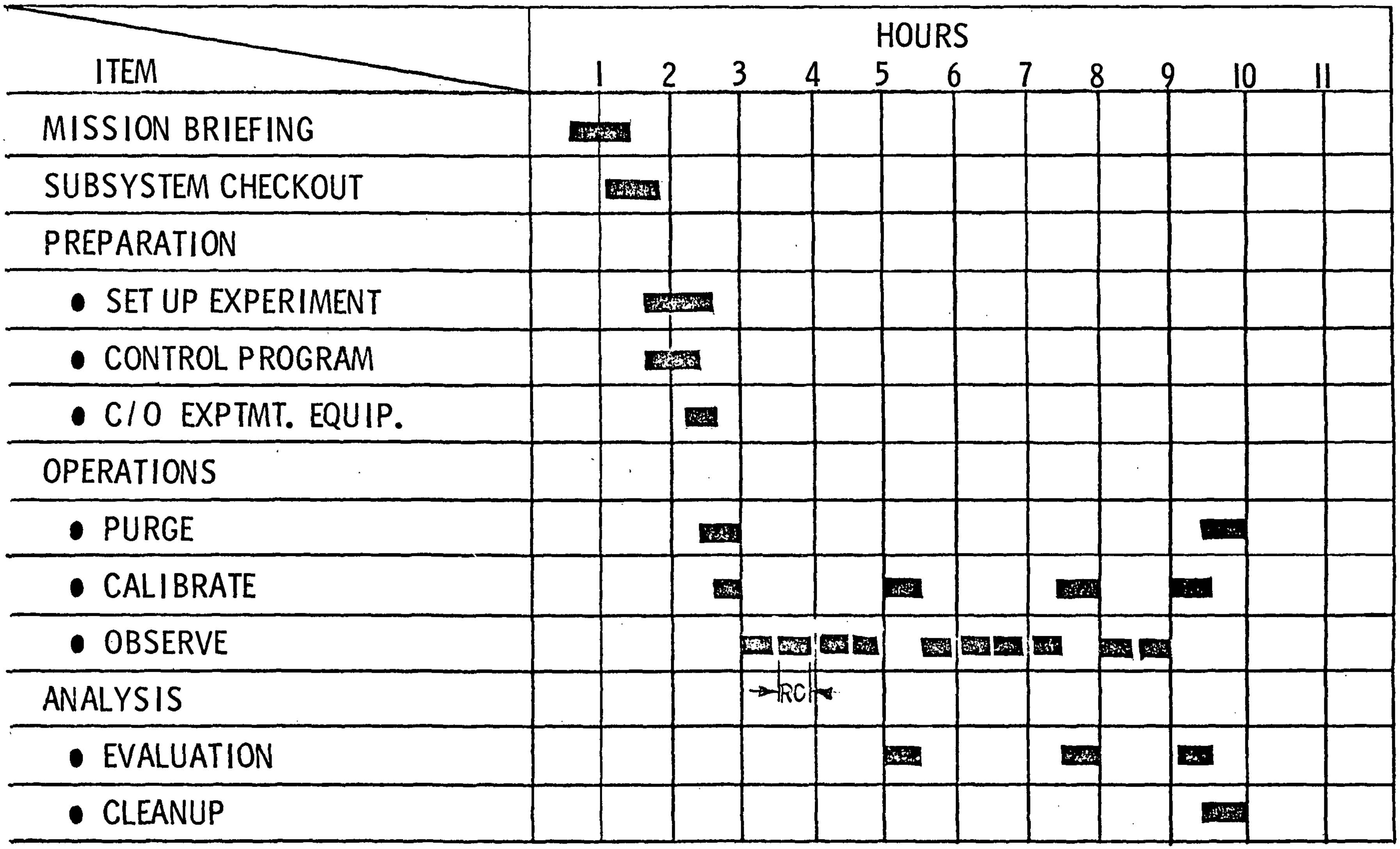
ORBITER-BOOSTER MATE/LAUNCH OPERATIONS/MISSION/RE-ENTRY AND LANDING



EXPERIMENT TIMELINE (TYPICAL)

THE ACPL MISSION EXPERIMENT TIMELINE DISPLAYED IS TYPICAL OF THE PLANNED ACTIVITY. THIS SEQUENCE WILL FOLLOW AN ENGINEERING PERIOD OF CHECKOUT, SETUP, AND STABILIZATION.

ACPL EXPERIMENT TIMELINE (TYPICAL)



SL 1 TIMELINE CONSIDERATIONS

THE CONSTRAINTS AND ASSUMPTIONS ARE SHOWN WITH NO MAJOR PROBLEMS NOTED.

ENGINEERING CHECKOUT OF THE SHUTTLE/SPACELAB WILL BE PRIME, WITH EXPERIMENT ACTIVITIES COMPLETING THE MISSION.

SL1 TIMELINE CONSIDERATIONS

CONSTRAINTS

- 7 DAY MISSION
- ACPL EXPERIMENT PRIORITY TBD*
- DAILY CREW TIME ALLOTMENTS
  - 3 EAT PERIODS @ 1 HOUR EACH
  - 2 PSA PERIODS @ 1 HOUR, 1 @ 1/2 HOUR
  - 1 SLEEP PERIOD OF 8 HOURS
  - TOTAL = 12 1/2 PAYLOAD SPECIALIST MAN HOURS
- VEHICLE MANEUVERS

ASSUMPTIONS

- DAILY CREW TIME ALLOTMENTS
  - 1/2 HOUR DAILY ACTIVITY PLANNING PERIOD
  - 2 5-1/2 HOUR WORK PERIODS
  - TOTAL = 11 1/2 HOURS
- THE FIRST CREW SLEEP PERIOD WILL COMMENCE APPROX. 14 HOURS AFTER LIFT-OFF
- 6 DAYS OF ACPL OPERATION

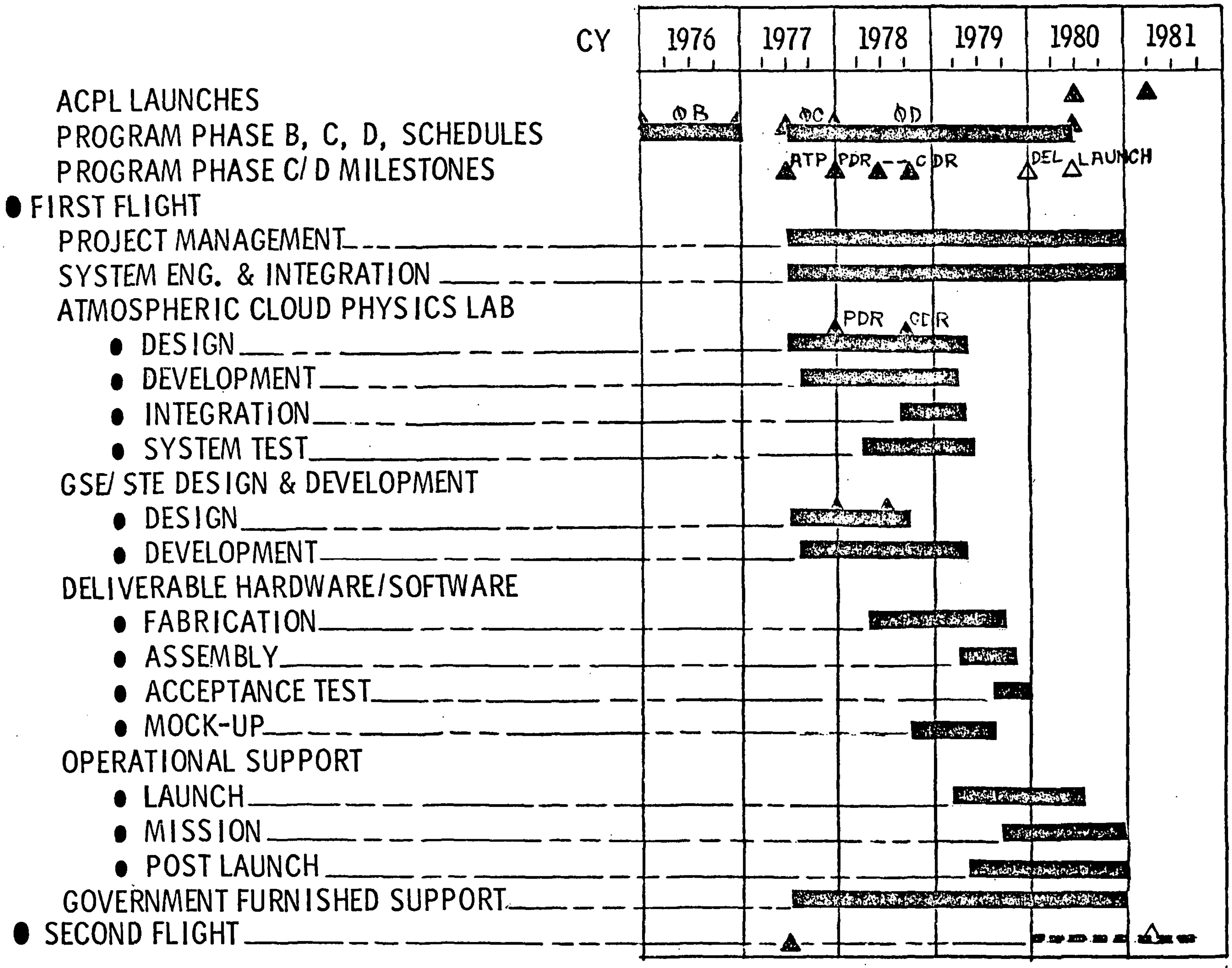
* VFI EXPERIMENT PRIME FOR SL#1

SCHEDULES

ACPL PROGRAM MASTER SCHEDULE

THE PHASE C/D PROGRAM SCHEDULE IS SHOWN AS KNOWN TO DATE. THE COORDINATED EFFORT OF DESIGNING/COSTING/PLANNING AND SCHEDULING ARE CENTERED ABOUT THIS SEQUENCE.

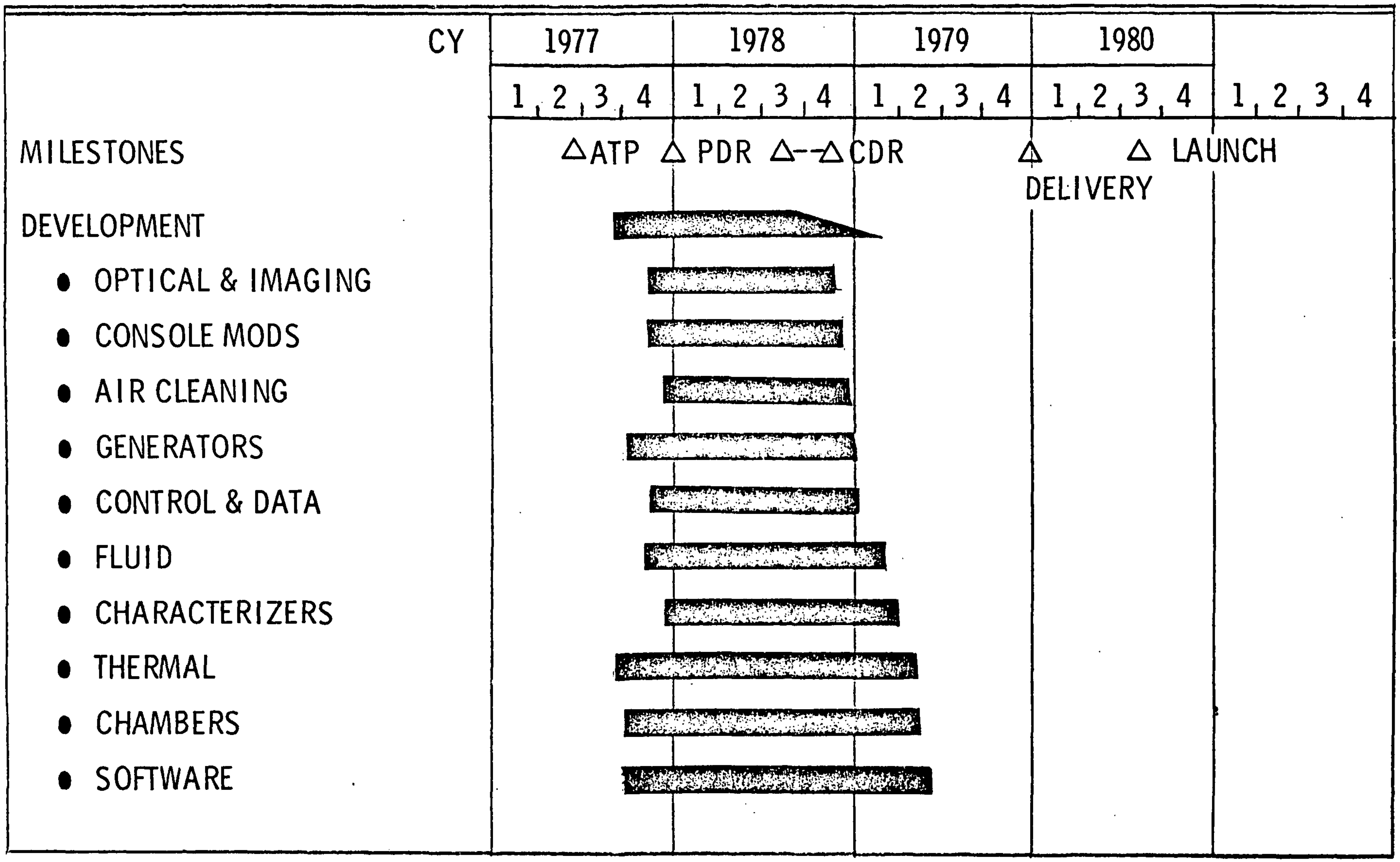
ACPL PROGRAM MASTER SCHEDULE



SUBSYSTEM DEVELOPMENT SCHEDULE

THE PHASE C/D SUBSYSTEM DEVELOPMENT ACTIVITIES ARE TIMELINED FOR EASY REFERENCE. THE LEVEL OF EFFORT MAY VARY DURING A DEVELOPMENT PERIOD BUT THE TOTAL LOADING WILL BE FAIRLY CONSISTENT, TO MINIMIZE COSTS.

ACPL SUBSYSTEM DEVELOPMENT SCHEDULE

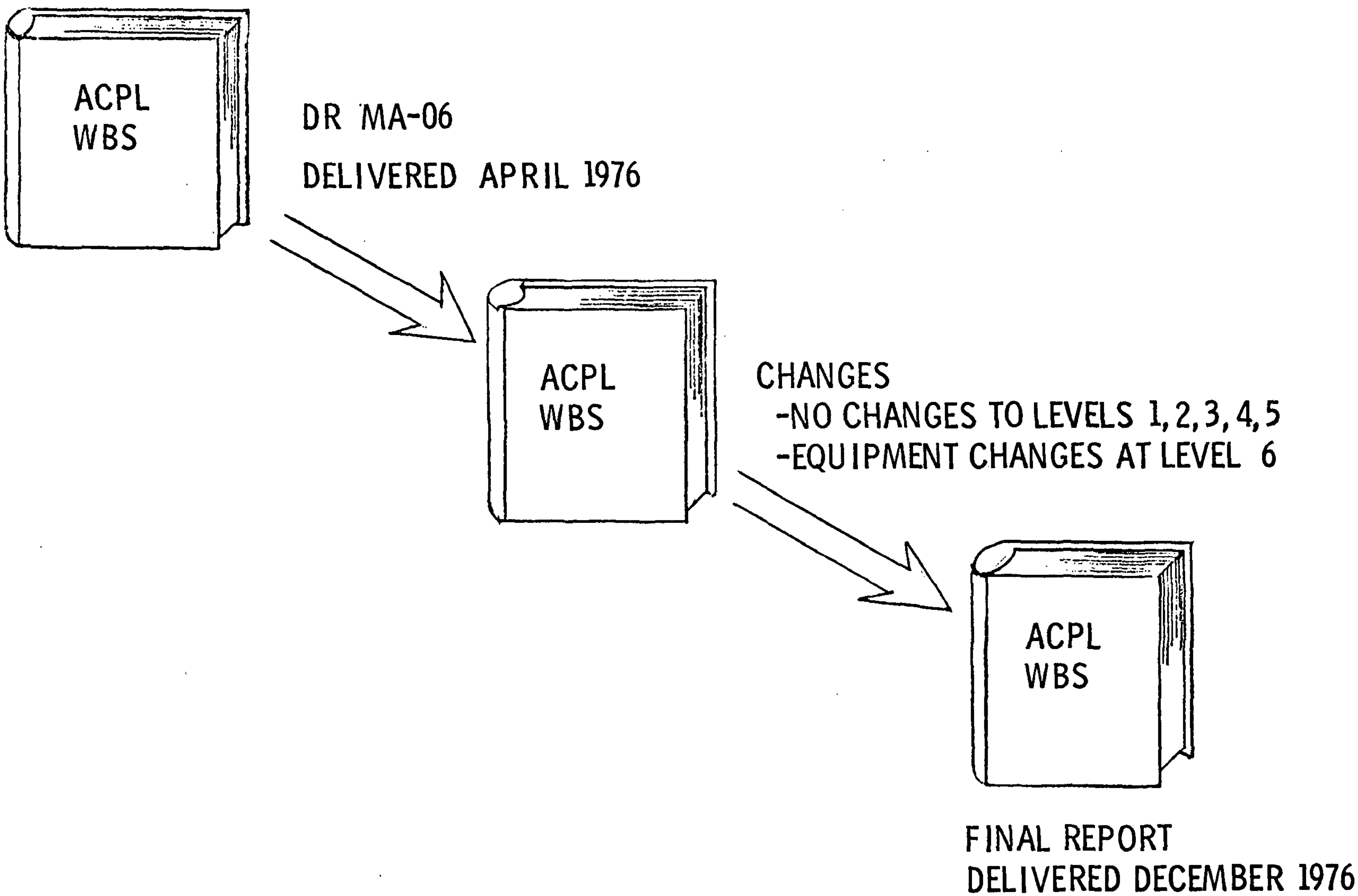


WORK BREAKDOWN STRUCTURE

WORK BREAKDOWN STRUCTURE

THE WBS IS A LIVING DOCUMENT THAT WILL BE UPDATED AND MAINTAINED AS A USEFUL MANAGEMENT TOOL DURING THIS PHASE. THE FINAL REPORT WILL BE PER DR MA-06 AT THE COMPLETION OF THE STUDY.

ACPL WBS

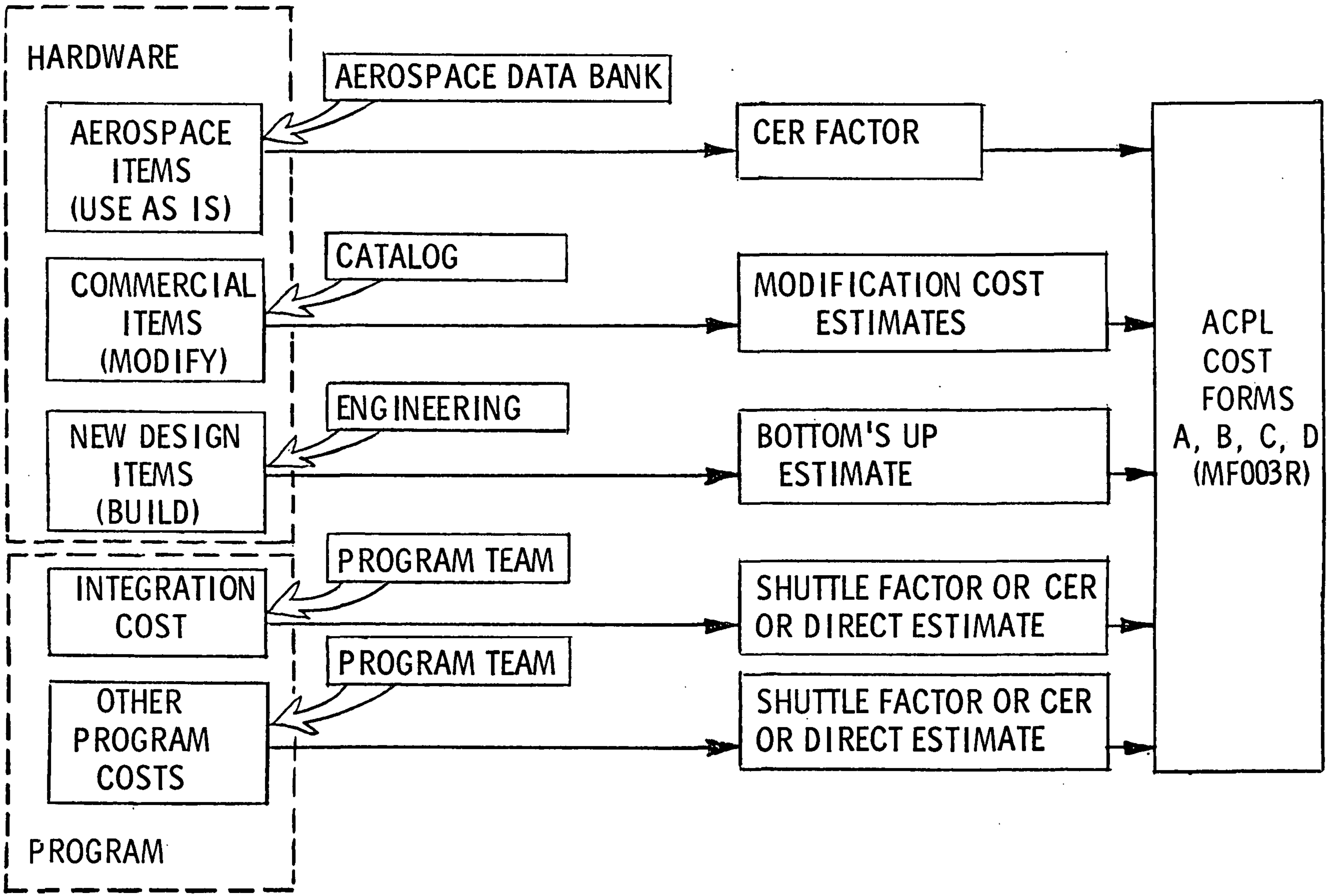

ACPL
WBS
DR MA-06
DELIVERED APRIL 1976
ACPL
WBS
CHANGES
-NO CHANGES TO LEVELS 1, 2, 3, 4, 5
-EQUIPMENT CHANGES AT LEVEL 6
ACPL
WBS
FINAL REPORT
DELIVERED DECEMBER 1976

COST

ACPL COST METHODOLOGY

THE METHODOLOGY ESTABLISHED FOR PHASE B ACCOUNTS FOR ALL ASPECTS OF THE HARDWARE SELECTION, MODIFICATION, AND/OR FABRICATION COST CYCLES PLUS OTHER PROJECT COST ADDERS. THIS PROCESS RESULTS IN COMPLETED FORMS COMPATIBLE WITH DR MF - 003R.

ACPL METHODOLOGY



COST ESTIMATING GROUND RULES

THE GROUND RULES FOR COSTING ARE CONSISTENT WITH THE REQUESTS OF DR MF - 003R.

COST ESTIMATING GROUND RULES

- ALL COSTS IN 1976 DOLLARS
- ADAPTATION OF AVAILABLE 1-G HARDWARE TO 0-G CAPABILITY WHEREVER FEASIBLE (VERSUS NEW DESIGN)
- COSTS INCLUDED FOR EXPERIMENT ONLY
- PRODUCTION OF EXPERIMENT HARDWARE AT GE-VF AND TYPICAL VENDOR PLANTS
- COSTS ARE TOTAL COST TO GOVERNMENT EXCLUDING PRIME CONTRACT FEE AND NASA PROGRAM MANAGEMENT/SYSTEMS SUPPORT COSTS
- COSTS ARE FOR PRELIMINARY PLANNING PURPOSES AND TRADEOFF STUDIES ONLY
- COSTS TO BE DEVELOPED AT OR BELOW THE LEVEL AT WHICH THEY ARE SPECIFIED OR REPORTING IN MF003R

COST TARGET SCHEDULE

THE COSTING SEQUENCE FOR PHASE B WILL BE PRESENTED AS SHOWN WITH CONTINUAL TRANSMISSION OF UPDATED INFORMATION AS OBTAINED.

COST TARGET SCHEDULE

MILESTONES	△	△	△	△
	REQUIREMENT REVIEW	CONCEPT REVIEW	INTERIM REVIEW	FINAL REVIEW
	PERCENT ALLOCATIONS	LEVEL 5 PRELIMINARY TARGETS FOR HARDWARE BLOCKS	LEVEL 5 PRELIMINARY TARGETS FOR ALL BLOCKS	PROGRAM TOTAL COST PER MF003R

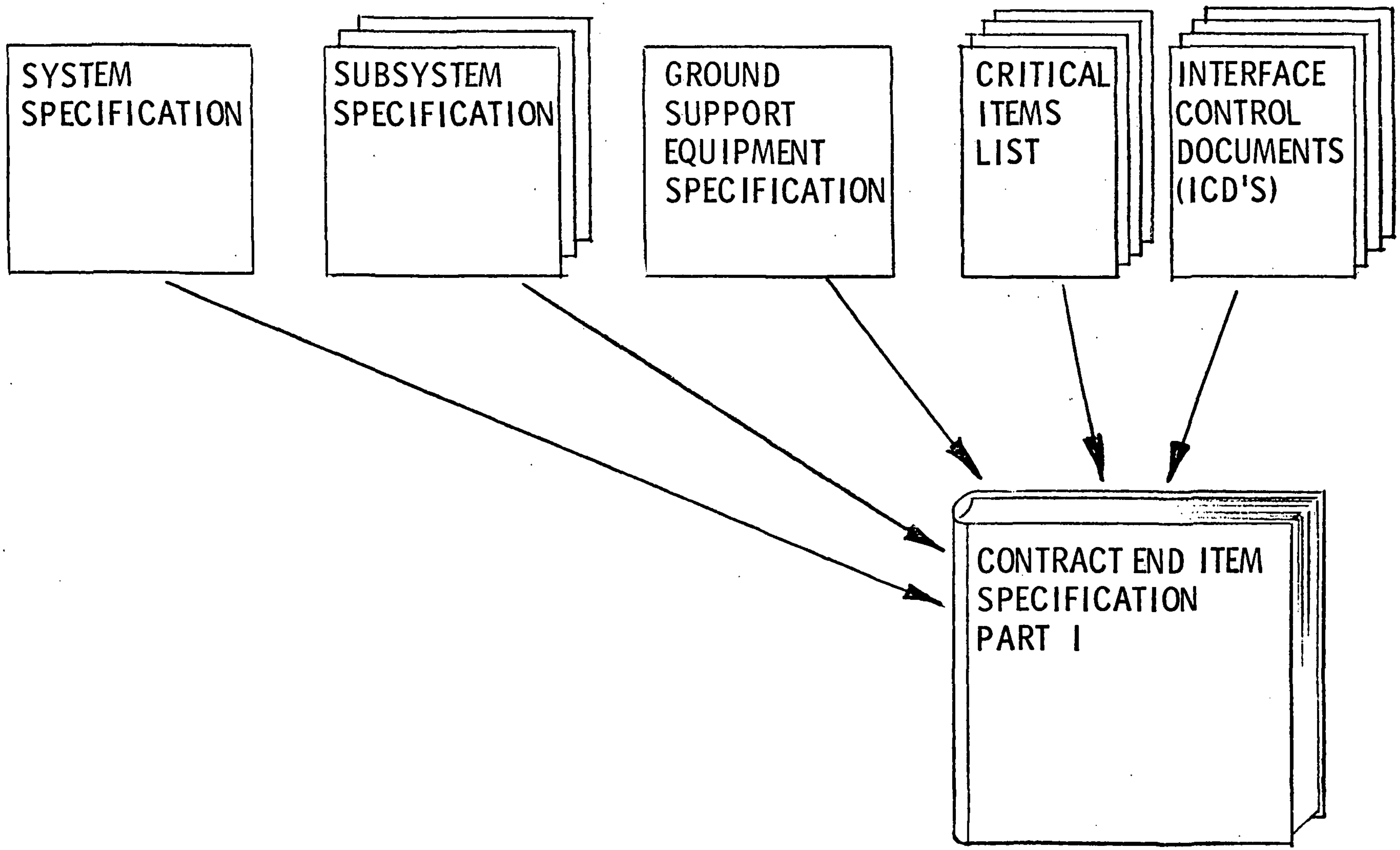
CEI/ICD'S

SPECIFICATIONS AND INTERFACE CONTROL DOCUMENTS

THE MAJOR ELEMENTS OF THE ACPL CONTRACT END ITEM SPECIFICATION-PART-I ARE SHOWN. CEI SPECIFICATION PART II WILL BE PREPARED BY GE DURING PHASE C/D CONTRACT. SPECIFICATION PREPARED IN ACCORDANCE WITH MM8040.12.

NOTE-NO CRITICAL ITEMS ENVISIONED AT THIS TIME.

SPECIFICATIONS AND INTERFACE CONTROL DOCUMENTS



ACPL ICD'S

ACPL INTERFACE DISCIPLINES WILL BE GROUPED INTO ICD'S, TO BE COMPATIBLE WITH NORMAL MSFC/NASA CATEGORIES.

MSFC ICD NUMBERS HAVE BEEN ASSIGNED.

ACPL ICD'S

FLIGHT ICD'S - ACPL TO S/L

- MECHANICAL - 44A00002
  - RACK MOUNTING
  - RACK COOLING
  - EXPERIMENT HEAT DISSIPATION
- ELECTRICAL - 44A00003
  - 200V 400 HZ
  - 28V DC
  - GROUNDING AND ISOLATION
- INSTRUMENTATION AND COMMUNICATION - 44A00004
  - SIGNAL DEFINITION

GROUND C/O ICD'S - ACPL GSE TO FACILITY

- ELECTRICAL - 44A00005
  - AC POWER
  - GROUNDING AND ISOLATION
- EQUIPMENT ARRANGEMENT - 44A00006
  - EQUIPMENT FOOTPRINT

PROCEDURAL ICD

- FLIGHT AND GROUND CHECKOUT - 44A00007
  - SPECIAL HANDLING
  - SPECIAL SEQUENCING

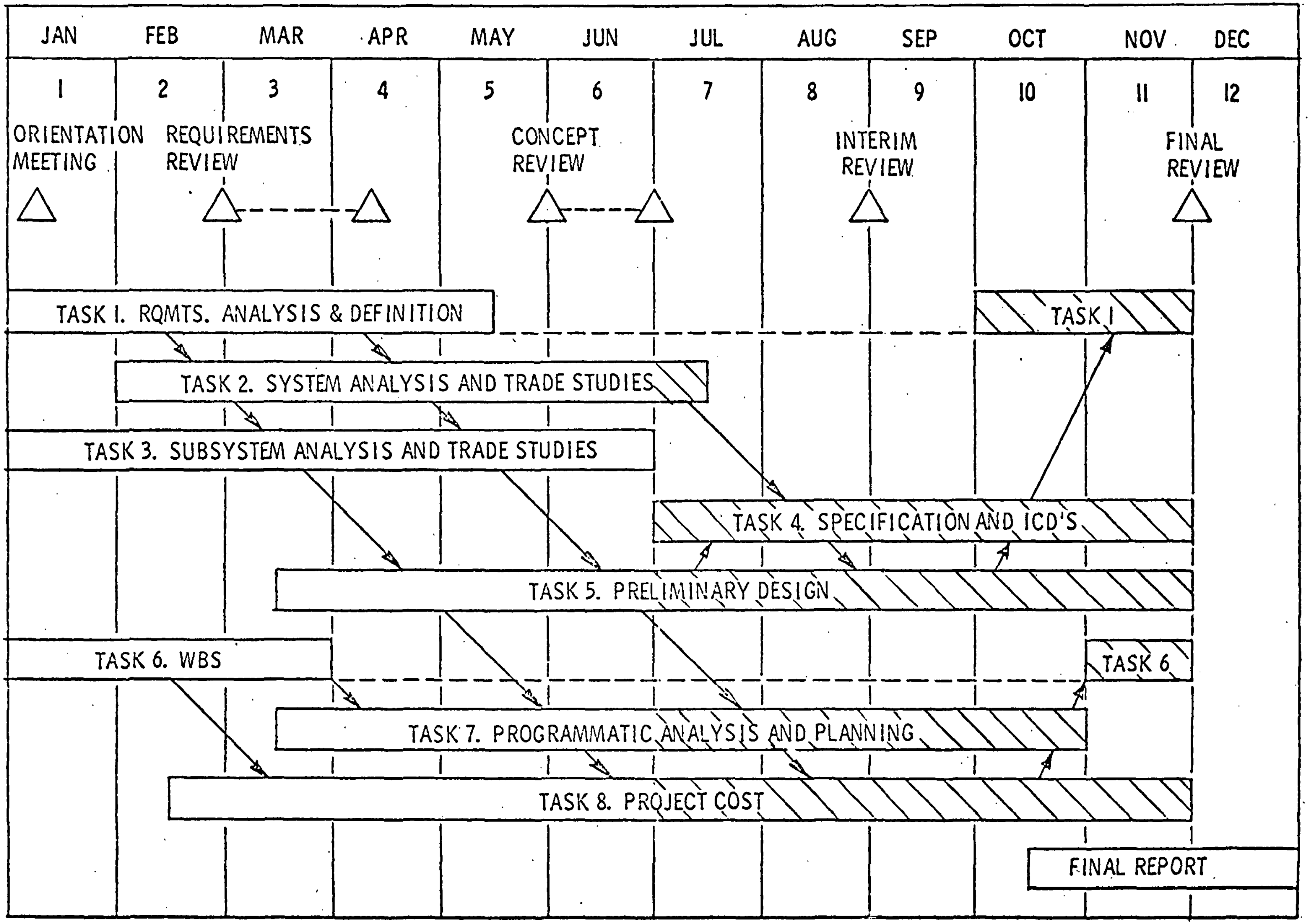
SUMMARY

R. GRECO

ACPL STUDY SUMMARY FLOW

THE REMAINDER OF THE ACPL STUDY EFFORTS ARE IDENTIFIED ON THE SCHEDULE. PRIMARY EMPHASIS IN THESE EFFORTS WILL BE DIRECTED TO REFINEMENT AND FINALIZATION OF THE ACPL DESIGN CONCEPT AND THE DEVELOPMENT OF THE PROGRAMMATIC ASPECTS OF THE ACPL PROJECT.

ACPL STUDY SUMMARY FLOW



GENERAL ELECTRIC

Space Division / Headquarters: Valley Forge, Pennsylvania ☐ Daytona Beach, Fla. ☐ Cape Kennedy, Fla. ☐ Evendale, Ohio ☐ Huntsville, Ala. ☐ Bay St. Louis, Miss. ☐ Houston, Texas ☐ Newport Beach, Calif.